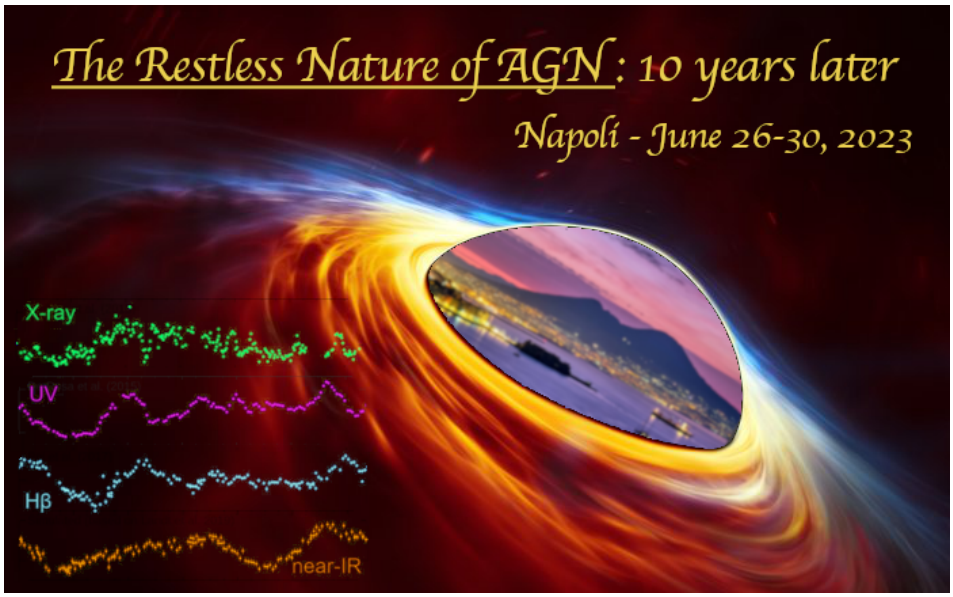
The restless nature of AGN: 10 years later



Report of Contributions

https://indico.unina.it/e/restlessagn2023

Contribution ID : **1** Type : **Poster**

The timescale and flux dependent lags of Mrk 110

Recent intensive reverberation mapping campaigns of AGN are opening a new window in the studies of the accretion geometry around super massive black holes. Here we present the X-ray/UV/optical lag spectrum of the high accretion rate AGN Mrk 110 during three epochs between 2017 and 2019. We monitored the source using Swift, Las Cumbres Observatory and the Zowada Observatory. During the first epoch we find a clear evidence for timescale dependent lags: on short timescales the consistent the system shows delays consistent with a disk-reverberation scenario; on longer timescales instead, the optical lags become of the order of several days, indicating the contribution from an extended reprocessor (most probably the broad line region). When looking at the following epochs, we also discover for the first time an evolution of the X-ray and the U band excess in a single source. The presence of correlation between these lags and the X-ray luminosity strongly suggests that a significant contribution from the broad line region to the whole lag spectrum. These result shed new light on the origin of the X-ray excess and demonstrate the need of new multi-epoch observations in order to fully constrain on the geometry on these systems.

Primary author(s) : VINCENTELLI, Federico (instituto astrofísico de canarias)

Presenter(s) : VINCENTELLI, Federico (instituto astrofísico de canarias)

Session Classification : Poster

Contribution ID : **4** Type : **Poster**

Variability-Selected Faint AGN from the Local Universe to the Epoch of Reionization

Current wide-field quasar surveys are not sensitive to low-luminosity active galactic nuclei (AGN), due to both flux limit and color selection effects. The absence of such objects will bias our understanding of AGN evolution, and limit the ability to distinguish between various models of the origin and seed evolution of supermassive black holes (SMBHs). Variability is an ubiquitous signature of AGN activity and has shown to be a powerful tool in finding low-luminosity AGN in high-redshift galaxy population. Previous studies on AGN variability are limited to low redshift bright sources, and they do not go deep enough to discover the faint, high redshift population. Near infrared variability traces the rest frame UV-optical regime of AGN at high redshift. JWST NIRCam surveys provide high spatial resolution, unprecedented depth and additional cadence suitable for time-lag studies. We conduct a research study to search for variable sources in the deep field areas that have been observed both in JWST Cycle-1 and in previous HST surveys, looking for faint, high-redshift AGN candidates. We catalog the near infrared variable sources from both datasets, identify AGN based on both catalog matching and image subtraction. Our preliminary result is able to recover known AGN and we expect to find ˜100 faint variable AGNs (m<27) at z=6 combining all deep field data. This will be the first variability selected faint high-redshift AGN sample. It will provide independent measurements of the faint end of AGN luminosity function, and pave the way for characterizing the evolution of SMBH accretion activities by studying their variability over wide range of redshift using future multiepoch JWST data.

Primary author(s) : Prof. FAN, Xiaohui (University of Arizona); Mr. TEE, Wei Leong (University of Arizona)

Presenter(s) : Mr. TEE, Wei Leong (University of Arizona)

Session Classification : Poster

Contribution ID : **5** Type : **Contributed talk**

Infrared Dust Echoes and Extreme Coronal Lines: SMBH Environments Unveiled by TDEs

Thursday, 29 June 2023 13:00 (15)

When stars approach the tidal radius of a supermassive black hole (SMBH) and find themselves unraveled, the resulting debris stream spirals toward the SMBH and creates a flare whose light can outshine the host galaxy. These tidal disruption events (TDEs) can be used for independent measures of black hole masses, and they offer new windows to study accretion onset and flaring mechanisms near SMBHs. Only recently, though, have TDEs offered us glimpses into the sub-parsec local environments near SMBHs. AT 2020mot is a typical UV/optical TDE, but is uniquely bright in the near-infrared and even shows a later enhancement in brightness along the tail of the light curve. This could be the first TDE to show two "dust echoes," indicative of concentric rings of thin dust within 0.1 parsecs of a SMBH, among the smallest scales at which dust has been inferred near SMBHs. Similarly, the recent event AT 2022upj is an extreme coronal line emitter (ECLE) that shares emission line diagnostics in common with the small subset of ECLEs designated as TDEs. This class of events has been interpreted as another form of a "light echo" of TDEs in gas-rich environments. Events like AT 2020mot and AT 2022upj are novel opportunities to peer into the closest material of otherwise invisible black holes in quiet galaxies. Studying these events will explore the fundamental connections between supermassive black holes, galaxy evolution, and accretion mechanics.

Primary author(s) : NEWSOME, Megan (UC Santa Barbara, Las Cumbres Observatory)

Presenter(s) : NEWSOME, Megan (UC Santa Barbara, Las Cumbres Observatory)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **6** Type : **Contributed talk**

What can we learn from correlated radio and X-ray variability?

Monday, 26 June 2023 15:30 (15)

High frequency radio emission may originate from scales as small as the innermost accretion disk, and can thus probe directly the relativistic electrons and the magnetic fields in the coronal gas of radio quiet AGN.

I will present simulations of the time evolution of the distribution functions of relativistic electrons following their injection due to a coronal reconnection event. The electrons cool through Compton scattering, producing a pulse of X-ray emission, and through synchrotron emission, producing a pulse of high frequency radio emission. Future simultaneous monitoring of X-ray and mm emission may allow to probe directly the coronal heating and cooling mechanisms.

I wil also briefly point out the false detections of correlated variability when two red light curves are correlated, as we found in a recent study of simultaneous radio and X-ray observation of three AGN. I will also describe how these biases can be minimised in future studies.

Primary author(s) : LAOR, Ari (Technion)

Presenter(s) : LAOR, Ari (Technion)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **7** Type : **Poster**

Early-stage AGN with extreme radio variability

Narrow-line Seyfert 1 (NLS1) galaxies are a class of active galactic nuclei (AGN) identified almost 40 years ago, but still not well understood. They are preferentially hosted by disk-like galaxies, and harbour fast-growing, low-mass supermassive black holes, accreting at high Eddington ratios. Some tens of NLS1s have been detected in gamma-rays, proving the presence of powerful relativistic jets in them. An intriguing subset of jetted NLS1s was discovered in late 2010s when seven previously radio-silent sources were detected at Jy-levels at 37 GHz at Metsähovi Radio Observatory (Finland). These sources proved to exhibit extremely high-amplitude radio variability, at levels previously unseen in AGN. This launched an extensive, still ongoing, investigation into these sources, utilising several facilities - such as the JVLA, VLBA, Effelsberg, OVRO, IRAM, GranTeCan, Swift, XMM-Newton, and Fermi - across the electromagnetic spectrum. In this talk I will summarise our efforts so far to understand and explain the nature of these extraordinary AGN.

Primary author(s) : Dr. JÄRVELÄ, Emilia (The University of Oklahoma, USA); Dr. BERTON, Marco; Dr. MYSERLIS, Ioannis; Dr. SAVOLAINEN, Tuomas; Prof. LÄHTEENMÄKI, Anne; Dr. KIEHLMANN, Sebastian; Dr. HOVATTA, Talvikki; Dr. ROMANO, Patrizia; Dr. FOSCHINI, Luigi

Presenter(s) : Dr. JÄRVELÄ, Emilia (The University of Oklahoma, USA)

Session Classification : Poster

Contribution ID : **9** Type : **Poster**

A universal variability structure function for disc emission?

The UV-optical continuum emission from accretion discs is known to vary on all timescales, from days to decades. Its statistical description as a random walk as well as deviations from that phenomenology have not given much insight into disc properties.

Here, we report our discovery of a universal variability structure function for quasars, which appears when the observer's clock ticks in units of an orbital timescale of the emitting disc material. This behaviour is consistent with magneto-rotational instabilities being the source of spontaneous variability.

Quasars may all follow the intrinsic relation tighly, while our observations could still be scattered in subtle ways as estimates of the orbital timescale are biased by dust extinction and the viewing angle of the disc. Also, we observe the random walk of windy discs to be offset from the main relation and discuss possible explanations. This line of inqury offers potential to probe the temperature profile of accretion discs independently of disc reverberation experiments, and should greatly benefit from forthcoming LSST data.

Primary author(s) : WOLF, Christian (Australian National University)

Presenter(s) : WOLF, Christian (Australian National University)

Session Classification : Poster

Contribution ID : **10** Type : **Contributed talk**

Live to Die Another Day: The Rebrightening of AT 2018fyk as a Repeating Partial Tidal Disruption Event

Stars that interact with supermassive black holes (SMBHs) can be either completely or partially destroyed by tides. In a partial tidal disruption event (TDE), the high-density core of the star remains intact, and the low-density outer envelope of the star is stripped and feeds a luminous accretion episode. The TDE AT 2018fyk experienced an extreme dimming event at X-ray (factor of >6000) and UV (factor of ~15) wavelengths ~500–600 days after discovery. Here I will present a model to explain the re-emergence of these emission components roughly 1200 days after discovery. We find that the source properties are similar to those of the predimming accretion state, suggesting that the accretion flow was rejuvenated to a similar state. We propose that a repeated partial TDE, where the partially disrupted star is on an ~1200 day orbit about the SMBH and periodically stripped of mass during each pericenter passage, powers its unique light curve. I will discuss the details of this model and the broader implications for the interpretation of other repeating nuclear transients.

Primary author(s) : Dr. WEVERS, Thomas (ESO)

Co-author(s) : Prof. COUGHLIN, Eric (Syracuse University); Dr. PASHAM, Dheeraj (MIT)

Presenter(s) : Dr. WEVERS, Thomas (ESO)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **11** Type : **Invited talk**

Review: Restless AGNs in the Legacy Survey of Space and Time

Wednesday, 28 June 2023 09:30 (30)

The Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST), aiming to begin in early 2025, will allow studies of the growing supermassive black holes (SMBHs) in active galactic nuclei (AGNs) on a truly massive scale. After a brief review of the LSST from an AGN perspective, I will describe the planned selection of tens of millions of AGNs using the LSST plus multiwavelength data, including with variability techniques. I will then highlight examples of exciting LSST AGN variability investigations including massive general AGN variability studies, photometric and spectroscopic reverberation mapping, microlensing of small-scale AGN structure, transient SMBH fueling events, and candidate binary SMBHs. I will end by briefly describing the LSST AGN Science Collaboration (AGN SC), currently composed of about 160 members spanning the globe. The AGN SC aims to lead many of the described investigations and is preparing for science with the petabyte deluge of LSST data.

Primary author(s) : Prof. BRANDT, William (Penn State University)

Co-author(s) : LSST AGN SCIENCE COLLABORATION (Multiple Institutions Worldwide)

Presenter(s) : Prof. BRANDT, William (Penn State University)

Session Classification : Current and Future Surveys

Contribution ID : **12** Type : **Contributed talk**

Uncovering Optical Quasar Variability After 20 Years

Tuesday, 27 June 2023 15:45 (15)

All quasars show a common stochastic variability, seen across various observed wavelengths and timescales. The origin of this variability is still uncertain, though variability in the optical is thought to stem from processes in the accretion disk around the SMBH. Time-series variability analysis presents a unique way to probe a quasar's geometry and dynamics in this regime without ultra-fine spatial resolution.

Optical quasar variability has been shown to be well-described by the Damped Random Walk (DRW) model, which is parameterized by a characteristic timescale $\tau_{\rm DRW}$ and amplitude $\sigma_{\rm DRW}$. A set of these parameters for a sample of quasars can be used to describe the variability statistically, which can then be related to physical properties of the accretion disk and its SMBH. For example, it has been shown that $\tau_{\rm DRW}$ correlates with the SMBH mass M_{BH}.

To investigate the validity and bias of the DRW model, in a recent work, we perform DRW-fitting analysis on multi-band 20-year-long optical quasar light curves for a sample of nearly 200 quasars, the longest baseline so far in DRW analysis.

We find that many of the timescales are still biased, though they are becoming less biased as baselines increase. We also find, using more flexible models, that the group (i.e., ensemble) power spectrum of the sample differs from the theoretical DRW model power spectrum on short timescales ($<$ a month), though matches it on longer timescales ($\sim$ months to years).

I will discuss the future of DRW and variability studies, involving reverberation mapping projects and correlations to certain timescales and instabilities within the disk. I'll also mention the help that future surveys and programs (e.g., LSST and DECam) will provide in this type of analysis.

Primary author(s) : STONE, Zachary (University of Illinois at Urbana Champaign)

Presenter(s) : STONE, Zachary (University of Illinois at Urbana Champaign)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **13** Type : **Contributed talk**

The universal shape of the X-ray variability power spectrum of AGN up to z ~ 3

Monday, 26 June 2023 17:15 (15)

We present a study of the ensemble X-ray variability of Active Galactic Nuclei (AGN) over a large range of timescales (20 ks ≤ T ≤ 14 yrs), redshift (0 ≤ z ⊠ 3), luminosities ($10^{40} \leq L_X \leq 10^{46}$ erg s^{-1}) and black hole (BH) masses 10^6 M 10^9). Through the use of the "variance–frequency diagram", as a viable alternative to the power spectral density (PSD), we show that the data collected from archival observations and previous literature studies are consistent with a universal PSD form which does not show evidence for systematic evolution of shape or amplitude with redshift or luminosity. We find new evidence that the PSD bend frequency depends on BH mass and, possibly, on accretion rate. We will discuss the implications for current and future AGN population and cosmological studies

Primary author(s) : Prof. PAOLILLO, Maurizio (Università di Napoli Federico II)

Presenter(s) : Prof. PAOLILLO, Maurizio (Università di Napoli Federico II)

Session Classification : X-ray continuum variability

Contribution ID : **14** Type : **Contributed talk**

Repeating TDEs in the quasi-periodic erupter GSN 069: Updates on QPE's properties and long-term evolution

X-ray Quasi-Periodic Eruptions (QPEs) are a novel X-ray variability phenomenon associated with supermassive black holes. QPEs are short-lived, high-amplitude, soft X-ray bursts typically recurring every few hours over an otherwise stable quiescent level. QPEs were first observed in the (repeating) TDE candidate GSN 069 by XMM-Newton (2019), and they have now been detected in the nuclei of several other galaxies. In my presentation, I will report on the current status of QPE's properties and long-term evolution in the best-monitored galaxy GSN 069, highlighting a possible QPE-TDE connection that may apply to other QPE sources as well.

Primary author(s) : Dr. MINIUTTI, Giovanni (Centro de Astrobiología (CAB), CISI-INTA, Spain); Dr. GIUSTINI, Margherita (Centro de Astrobiología (CAB), CSIC-INTA, Spain); Dr. ARCODIA, Riccardo (MIT Kavli Institute for Astrophysics and Space Research, Cambridge (MA), USA); SAXTON, Richard D. (Telespazio-Vega UK for ESA, European Space Astronomy Centre (ESAC), Spain)

Presenter(s) : Dr. MINIUTTI, Giovanni (Centro de Astrobiología (CAB), CISI-INTA, Spain)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **15** Type : **Poster**

On the properties of corona in Seyfert 1 galaxies

In the radio-quiet category of active galactic nuclei (AGN), the observed X-ray emission is believed to originate in the hot corona situated close to the vicinity of the accretion disk. Despite the numerous X-ray studies on AGN, we still do not have a clear understanding of the nature of the corona, such as its geometry, shape, location and the physical processes that power it. Parameters that can put constraints on the nature of the X-ray corona in AGN are the power law index and the high energy cut-off in the observed X-ray continuum. During the last decade, there has been progress in our understanding of the corona in AGN, owing to the availability of high signal-to-noise data covering a wide range of energies from NuSTAR. Utilizing the data from NuSTAR, we have carried out a systematic investigation of the coronal properties of a sample of about 140 Seyfert 1 type AGN. Of these, we could determine the temperature of the corona is about 36 sources from the physical model fit to the observed X-ray spectra. From these measurements, we investigated various correlations between the properties of the corona and the physical properties of the AGN. Also, from analysis of multi-epoch data available for a few sources, we found evidence for variation in the temperature of the corona in two sources, namely MCG+08-11-011 and NGC 3227. Details of the results will be presented in the meeting.

Primary author(s) : Ms. PAL, Indrani (Indian Institute of Astrophysics)

Presenter(s) : Ms. PAL, Indrani (Indian Institute of Astrophysics)

Session Classification : Poster

Contribution ID : **16** Type : **Contributed talk**

Extracting AGN variable component properties with long-term optical photometry

Tuesday, 27 June 2023 16:00 (15)

I present initial results from long-term (*U*)*BV*(*u'*)*g'r'* photometry with the Las Cumbres Observatory robotic telescope network of a sample of ˜80 AGN with a cadence of typically 1 month. The sample includes multiple representatives from the following AGN sub-categories: NLS1 with strong Fe II emission; Seyferts with Keplerian rotator broad line profiles; Seyferts with strong broad He II emission; obscured AGN; known Changing-look AGN; blazars. I utilise the flux variation gradient (FVG) method to determine the colour of an AGN's variable component. In most cases the FVG method also enables the separation of the variable and non-variable optical flux contributions and the estimation of the nuclear reddening. Since commencing this programme three years ago variations have been confirmed in >80% of the sample, and nuclear colours with an accuracy of 0.1 mag or better in *B*-*V* have been determined for half of the observed AGN. From these colours I determine the intrinsic variable component optical flux distributions and examine if and how these differ between the AGN sub-categories mentioned earlier. I briefly discuss how this constrains physical models of the variable parts of these AGN. Additional results include the indication that NLS1 with strong Fe II emission display lower optical variability amplitudes and that the reddening law for the dust obscuring some AGN differs to that applicable to typical interstellar dust.

Primary author(s) : WINKLER, Hartmut (University of Johannesburg)

Presenter(s) : WINKLER, Hartmut (University of Johannesburg)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **17** Type : **Contributed talk**

XMM-Newton Highlights of Black Hole Variability

Wednesday, 28 June 2023 11:00 (15)

With about 380 refereed papers published each year, XMM-Newton is one of the most successful scientific missions of ESA ever. Observation of AGNs and their variability is one of the main research fields covered by the observing program of the mission. The talk highlights XMM-Newton contributions to our current view of Black Holes variability. XMM-Newton observations provide a unique opportunity to study the vicinity of Supermassive Black Holes (SNBH) and constrain the understanding of the underlying accretion physics. The main focus of the talk will be the discussion of recent scientific highlight results based on XMM-Newton observations of SMBHs.

Primary author(s) : Dr. NORBERT, Schartel (ESA)

Presenter(s) : Dr. NORBERT, Schartel (ESA)

Session Classification : Current and Future Surveys

Contribution ID : **18** Type : **Contributed talk**

Searching for different AGN populations in massive datasets with Machine Learning

Friday, 30 June 2023 17:30 (15)

Brightness variations of active galactic nuclei (AGNs) provide an alternative way to identify AGN candidates that could be missed by more traditional selection techniques. In this talk, I will first present a new variability and color-based classifier, designed to identify multiple classes of transients, persistently variable, and non-variable sources, from the Zwicky Transient Facility (ZTF) Data Release 11 (DR11) and ZTF forced aperture photometry light curves of extended and point sources. The main motivation of this model is to identify AGN candidates, but it can be used for more general time-domain astronomy studies. We used a hierarchical local classifier per parent node approach, to classify a total of 17 classes, including non-variable objects, transients, and stochastic and periodic variables. With this model, we have been able to identify AGN candidates at different redshifts and with different ranges of mass and luminosity. Then, I will present an anomaly detection (AD) technique designed to identify AGN light curves with anomalous behaviors. The main aim of this work is to identify changing-state AGNs (CSAGNs) at different stages of the transition, but it can also be used for more general purposes. We modeled ZTF DR5 light curves of 230,458 AGNs with a Variational Recurrent Autoencoder (VRAE) architecture, that allowed us to obtain a set of attributes from the VRAE latent space that describes the general behavior of our sample. These attributes were then used as features for an Isolation Forest (IF) algorithm. We used the VRAE reconstruction errors and the IF anomaly score to select a sample of 8810 anomalies. Bogus candidates dominate these anomalies, but we were able to identify promising AGNs with anomalous variations.

Primary author(s) : Dr. SANCHEZ SAEZ, Paula (ESO)

Presenter(s) : Dr. SANCHEZ SAEZ, Paula (ESO)

Session Classification : Methods and techniques

Contribution ID : **19** Type : **Contributed talk**

Stellar graveyards in AGN disks - prospects for multi-messenger transients

Tuesday, 27 June 2023 12:45 (15)

Active Galactic Nuclei (AGNs) can collect stars and stellar remnants from the vicinity of the galactic center into the inner plane of the AGN disk. The dense population of stellar objects give rise to a wealth of interactions from stellar-mass black hole collisions to the tidal disruption of stars on stellar-mass black holes. These transients are promising multi-messenger sources from gravitational waves to radiation across the electromagnetic spectrum. I will discuss what we currently know about AGN-assisted mergers and disruptions so far, and highlight the most promising future observational directions.

Primary author(s) : BARTOS, Imre

Presenter(s) : BARTOS, Imre

Session Classification : Accretion and variability theory

Contribution ID : **20** Type : **Poster**

The rise and fall of the nuclear transient PS16dtm

Thanks to the advent of large-scale optical surveys, a diverse set of flares from the nuclear regions of galaxies has recently been discovered. These include the disruption of stars by supermassive black holes at the centres of galaxies - nuclear transients known as tidal disruption events (TDEs). Active galactic nuclei (AGN) can show extreme changes in the brightness and emission line intensities, often referred to as changing-look AGN (CLAGN). Given the physical and observational similarities, the interpretation and distinction of nuclear transients as CLAGN or TDEs remains difficult. One of the obstacles of making progress in the field is the lack of well-sampled data of long-lived nuclear outbursts in AGN. I will present PS16dtm, a nuclear transient in a Narrow Line Seyfert 1 (NLSy1) galaxy which has been proposed to be a TDE candidate. I will show our multi-year spectroscopic and photometric study of PS16dtm, which can help us to better understand the outbursts originating in NLSy1 galaxies.

Primary author(s) : Dr. PETRUSHEVSKA, Tanja (University of Nova Gorica); Prof. ILIC, Dragana (University of Belgrade); Dr. LELOUDAS, Giorgos (Technical University of Denmark)

Presenter(s) : Dr. PETRUSHEVSKA, Tanja (University of Nova Gorica)

Session Classification : Poster

Contribution ID : **22** Type : **Poster**

A study of optical spectral of extreme variability quasars in their various states

Extremely variable quasars (EVQs) are a population of sources showing large optical photometric variability revealed by time-domain surveys. The physical origin of such extreme variability is yet unclear. We construct the largest-ever sample of 14,012 EVQs using photometric data spanning over > 15 years from SDSS and Pan-STARRS1 and divided them into five sub-sample according to their spectroscopic brightness relative to their mean photometric brightness. By comparing their composite spectra to those of the redshift, blackhole mass, and bolometric luminosity matched control sample, we find EVQs exhibit clearly bluer (redder) continuum during bright (dim) states, consistent with the "bluer-when-brighter" trend widely seen in normal quasars. The emission lines in EVQs have systematically larger equivalent widths and exhibit intrinsic Baldwin effect (iBeff) except for Hβ. A broad red wing in CIV is founded for EVQs which might due to the sub-structure of broad line reigion. We further verify our above findings with a EVQ sub-sample containing 1476 repeatedly spectrally observed sources. In addition, we compare EVQs' Hβ line variability with that of archived 36 changing-look quasars (CLQs) and find that the CLQs could be a natural selection results given the absence of iBeff in Hβ line. That premise can also explain the scarcity of MgII and CIV CLQs.

Primary author(s) : REN, Wenke (University of Science and Technology of China)

Co-author(s) : Prof. WANG, Junxian (University of Science and Technology of China); CAI, Zhen-Yi (USTC); GUO, Hengxiao

Presenter(s) : REN, Wenke (University of Science and Technology of China)

Session Classification : Poster

Contribution ID : **24** Type : **Contributed talk**

The AGN Variability Archive - AVA: A legacy database of intensive broadband reverberation mapping experiments

Monday, 26 June 2023 10:15 (15)

AGN variability carries information about the geometry of the accretion flow which is usually unaccessible to direct imaging methods. In particular, the reverberation signals at optical wavelengths of reprocessed high-energy photons provide insight into the size of the disc itself as well as inclination, mass accretion rate and the temperature profile of the disc itself. Over the last decade, we have developed the intensive broadband reverberation mapping technique combining the capabilities of Swift and Las Cumbres Observatory (LCO) to perform long-term (multiple years), high-cadence (sub-day), multi-wavelength (X-rays to NIR) experiments on ˜30 local AGN. These IBRM experiments have enabled stringent tests on the predictions of accretion theory and shown disagreements, catapulting new avenues to understand AGN variability. In this talk, I will review the main outcomes of the past IBRM campaigns, with particular focus on a high Eddington accretion source PG 1119+120. Our spectral and temporal decomposition allowed us to retrieve the signal of two components; a fast signal consistent with the X-ray reprocessing scenario, and a slow signal with a spectral energy distribution consistent with diffuse continuum emission from the broad-line region. I will also present the launch of our open-source database - AGN Variability Archive (AVA). This legacy database of processed light curves and spectra of ˜10 years of observations taken by both Swift and LCO will enable further studies in accretion flows of supermassive black holes.

Primary author(s) : HERNANDEZ SANTISTEBAN, Juan (University of St Andrews); Prof. HORNE, Keith (University of St Andrews); Mr. DONNAN, Fergus (University of Oxford); Dr. EDELSON, Rick

Presenter(s) : HERNANDEZ SANTISTEBAN, Juan (University of St Andrews)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **25** Type : **Contributed talk**

Broad spectral line variability of the changing-look AGN NGC 3516: Role of a dusty broad line region

Thursday, 29 June 2023 16:15 (15)

Here we present our study of the variability of the broad Hbeta line profile of the “changing look” active galactic nucleus (CL-AGN) NGC 3516 over a long period (from 1996 to 2021). We model the broad line profiles assuming that there is emission from the accretion disc superposed with emission from a surrounding region that is outside the disc. We find that in the Type 1 activity phase (i.e., when the strong broad emission lines are observed), the broad line region (BLR) is very complex. There is a clear disc-like BLR contributing to the broad line wings and an additional intermediate line region (ILR) contributing to the line core. In the high activity phase, the ILR emission is close to the center of the line (slightly shifted to red in some cases), whereas in the low activity phase (i.e., Type 2 phase), the ILR component is clearly shifted to blue, indicating outflow. At different activity stages, the complex BLR structure can be detected, indicating that the gas motion remains constant but the line emission becomes weak. This may be caused by dust entering the interior of the BLR during the low activity stage, forming a dusty BLR. This leads to a decrease in ionization and recombination rates, so that the broad lines almost disappear.

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Presenter(s) : Prof. POPOVIC, Luka C. (Astronomical Observatory, Belgrade)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **27** Type : **Poster**

Evidence for short-term column density variability in the nearby changing-look Compton thick AGN NGC 1358: results from a multi-year NuSTAR-XMM-Newton monitoring to characterize the obscuring medium nearby accreting supermassive black holes

In this talk, I will present the results of a multi-epoch monitoring with NuSTAR and XMM-Newton of NGC 1358, a heavily obscured AGN whose properties made it an ideal changing look candidate.

The source was indeed found to be highly variable in line-of-sight column density (NHlos) over time-scales from weeks to years, even transitioning from a Compton thick state (NHlos>1E24 cm-2) to a Compton thin one. By measuring both luminosity and column density variability over such a wide range of time-scales, we found a a tentative anti-correlation between the two parameters: the more luminous the AGN, the smaller the amount of NHlos. Such a result can be understood in the framework of Chaotic Cold Accretion clouds driving recursive AGN feedback.

Besides this important result, our monitoring campaign proved how a multi epoch X-ray monitoring is key to simultaneously constraining the three otherwise highly degenerate parameters that define the obscuring medium geometry: the torus average column density and covering factor, and the inclination angle between the torus axis and the observer.

In the final part of the talk, I will briefly discuss how we plan to soon extend this multi-epoch approach to a larger sample of heavily obscured, nearby AGN, to better characterize the properties of the obscuring material surrounding accreting supermassive black holes, as well as constrain AGN feeding models.

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Presenter(s) : MARCHESI, Stefano (Università di Bologna)

Session Classification : Poster

Contribution ID : **28** Type : **Poster**

Echo mapping of NGC 7469 with ground and space-based observations

The disk-reverberation is a leading technique extensively used to study the size and structure of the accretion disk. However, the observed lag spectrum does not agree with the theoretical prediction. The observed time lags are often 2-3 times higher than the expected lags under the first-order reprocessing from the standard accretion disk. This discrepancy motivates us to explore the disk reverberation by modeling the accretion disk or including the contribution from the diffuse reprocessor to explain the observed time lags. We study one of the nearest Seyfert galaxies NGC 7469 using the high cadence ground-based observations from the Las-Cumbres Observatory (LCO) and Swift-UVOT. Our results agree with the general finding of time lags which are 2-3 times higher than the expected lags. I will discuss the time lags and the flux-flux study along with the total energy budget in the standard reprocessing scenario.

Primary author(s) : PRINCE, Raj (Center for Theoretical Physics, Warsaw, Poland)

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Presenter(s) : PRINCE, Raj (Center for Theoretical Physics, Warsaw, Poland)

Session Classification : Poster

Contribution ID : **29** Type : **Contributed talk**

Extreme variability in galactic nuclei detected with eROSITA

Wednesday, 28 June 2023 12:30 (15)

The eROSITA all-sky X-ray survey has provided the basis for a large-scale search for extreme X-ray variability in extragalactic objects associated with accretion changes in AGN. We have combined the survey dataset with a multi-wavelength follow-up campaign of the most variable objects. The follow-up observations include optical spectroscopy and X-ray and UV observations. This presentation will cover the results of our search for extremely variable AGN based on at least four epochs of available eROSITA data. Our sample consists of ˜2200 vetted extragalactic sources with significant X-ray changes. As part of our follow-up, we have collected optical spectroscopic follow-up on ˜350 objects, including repeat spectroscopy for 40% of these. I will introduce our sample selection criteria, statistics on the detected X-ray variability, and the observed correlation with optical 'changing-look' behaviour. I will also briefly summarise some of the most interesting individual sources. Finally, I will discuss our results in the context of the link between extreme X-ray and optical variability and the time scales involved in large-scale accretion changes around SMBHs.

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Presenter(s) : Dr. HOMAN, David (Leibniz-Institut für Astrophysik Potsdam)

Session Classification : Current and Future Surveys

Contribution ID : **31** Type : **Poster**

Fast variability of the optical polarization in blazars

Blazars are relativistic jet dominated active galactic nuclei, whose emission in the optical region is mostly synchrotron in nature and therefore – polarized. We monitored several objects on intra-night time scales in order to study the changes in their linear polarization parameters in different colours. Our first results suggest the presence of rapid changes in both – polarization degree and the electric vector orientation even within a few hours. The intra-night polarization variability in many of these blazars is studied for the first time at such an extent. Our study can have significant impact on the detailed modelling of the relativistic jet emission mechanisms.

Primary author(s) : Dr. BACHEV, Rumen (IA-NAO, BAS); Dr. STRIGACHEV, Anton (IA-NAO, BAS)

Presenter(s) : Dr. BACHEV, Rumen (IA-NAO, BAS)

Session Classification : Poster

Contribution ID : **32** Type : **Contributed talk**

shocks and variabilities in relativistic AGN jet

Friday, 30 June 2023 12:00 (15)

One of the main scenarios to account for the multi-wavelength flux variability observed in relativistic jets of active galactic nuclei (AGNs) is based on diffusive shock acceleration of a population of relativistic electrons on internal shocks of various origins. To understand the physical processes associated with the observed multi-wavelength emission maps and light curves, we investigate the physics of the shocks in AGN jet. We simulate variable relativistic jets using the resolving the relativistic magneto-hydrodynamic simulation of fluid equation and the distribution of non-thermal electrons that are injected in shock regions. Synchrotron emission and radiative transfer are calculated in the post-processing for given observation angles and frequencies. With our scenario, we were able to explain the appearance of trailing components behind the leading injected variability. The latter destabilizes the jet, causing the emergence of oscillating standing shocks and relaxation shocks. Emissions from these regions can dominate the overall flux or lead to “flare echos” in the light curve.

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Presenter(s) : MELIANI, zakaria (Observatoire de Paris)

Session Classification : Radio loud AGN

Contribution ID : **33** Type : **Contributed talk**

The Optical-to-X-ray continuum variability of AGN: thermal fluctuation rather than reprocessing?

Monday, 26 June 2023 12:30 (15)

From optical to X-ray, the variable continuum emissions of AGN are generally found to be correlated with variations at longer wavelengths lagging the shorter ones. Both the correlation and the lag-wavelength relation are usually understood within the widespread X-ray reprocessing scenario. However, both of them do not always preserve and challenge the reprocessing scenario. In recent years, we (Cai et al. 2016, 2018, 2020) upgrade the inhomogeneous thermal fluctuation model proposed by Dexter & Agol (2011), by introducing a common larger-scale fluctuation (as a result of the propagation and mixing of local fluctuations, likely, by magnetic fields allover the accretion disk) and suggesting a new origin for the continuum lag (as a result of the differential regression capability of local fluctuations responding to the large-scale fluctuation). Now, the new thermal fluctuation scenario can account for several observational properties of AGN variability, including the correlation and lag across the X-ray/UV/optical and the timescale-dependent color variation, and may shed new light on comprehending the UV/optical continuum variations and the relation to X-ray for AGN.

Primary author(s) : Dr. CAI, Zhen-Yi

Co-author(s) : Dr. WANG, Jun-Xian

Presenter(s) : Dr. CAI, Zhen-Yi

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **34** Type : **Contributed talk**

Multi-messenger observations of supermassive black hole binaries

Thursday, 29 June 2023 17:15 (15)

Supermassive black hole binaries are a natural end product of galaxy mergers and should be common in galactic nuclei. They produce bright electromagnetic emission and can be identified as quasars with periodic variability in time-domain surveys. They are also promising sources of low-frequency GWs soon to be detected by pulsar timing arrays (PTAs) with PTAs and time-domain surveys probing the same population of binaries. I will discuss the combination of time-domain observations with PTA data in a multi-messenger stream, the parameter space of binaries for which this combination is possible and the advantages of multi-messenger observations (e.g., improved parameter estimation).

Primary author(s) : CHARISI, Maria (Vanderbilt University)

Presenter(s) : CHARISI, Maria (Vanderbilt University)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **37** Type : **Contributed talk**

Probing Accretion Disk Structure with Long Lags in AGN Photometry

Monday, 26 June 2023 11:45 (15)

I will discuss the use of longer timescale "negative" lags, where the variability in high frequency bands lags the corresponding variability at low frequency, as a probe of accretion disk structure. Traditional reverberation mapping uses lags of variations in AGN photometry from high frequency to low frequency wavebands on the light-crossing timescale which come from the reprocessing of light in different temperature regions of the disk. The long negative lag, on the other hand, is due to fluctuations in the outer part of the UV/optical region of the disk that are accreted inward on the inflow timescale. Because the inflow rate also depends on disk properties, unlike the speed of light, these long lags can provide additional information about disk structure. Standard disk models predict the inflow timescale is on the order of hundreds of years. However, recent 3D radiation magnetohydrodynamic simulations of AGN disks and analysis of high-cadence, long baseline observations of Fairall 9 suggest that in the UV/optical region of the disk, the inflow timescale can be on the order of only 100 days, not years. This much shorter lag timescale would make the detection of long lags possible with long baseline observations from instruments such as SWIFT or Vera C. Rubin Observatory. I will outline the underlying theory of these long lags, show results from 3D radiation magnetohydrodynamic simulations of disk models beyond the standard disk model, and also present some candidate long lags.

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Presenter(s) : SECUNDA, Amy (Princeton University)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **38** Type : **Contributed talk**

Changing-look AGN in the BAT AGN Spectroscopic Survey

Thursday, 29 June 2023 10:15 (15)

Changing-look (CL) AGN are unique probes of accretion onto supermassive black holes (SMBHs), especially when simultaneous observations in complementary wavebands allow investigations into the properties of their accretion flows. I will present the results of a search for CL behaviour in 412 Swift-BAT detected AGN with multiple epochs of optical spectroscopy from the BAT AGN Spectroscopic Survey (BASS). 125 of these AGN also have 14-195 keV ultra-hard X-ray light curves from Swift-BAT which are contemporaneous with the epochs of optical spectroscopy. We have discovered eight new CL events, where the appearance or disappearance of broad Balmer line emission leads to a change in the observed Seyfert type classification. Combined with known events from the literature, 21 AGN from BASS are now known to display CL behaviour. Nine CL events have 14-195 keV light curve coverage, and five of these CL events can be associated with significant changes in their 14-195 keV flux from BAT. The ultra-hard X-ray flux is less affected by obscuration and so these changes in the 14-195 keV band suggest that the majority of our CL events are not due to changes in line-of-sight obscuration, and instead must be due to changes in the structure of the accretion disk and broad line region. We derive a CL rate of 0.7-6.2 per cent on 10-25 yr time-scales, and show that many transitions happen within at most a few years. Our results motivate further multiwavelength observations with higher cadence to better understand the variability physics of accretion onto SMBHs.

Primary author(s) : TEMPLE, Matthew

Presenter(s) : TEMPLE, Matthew

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **39** Type : **Contributed talk**

Still alive and kicking: a significant outburst in changing-look AGN Mrk 1018

Thursday, 29 June 2023 16:30 (15)

Mrk 1018 is an extremely unique changing-look AGN, which has already changed type twice. Almost a decade ago, it returned from a Seyfert type 1 to its original classification of a Seyfert type 1.9. We have been monitoring Mrk 1018 in the u'-band with STELLA since this last major transition. In 2020, our long-term optical monitoring program detected the most significant outburst over the last few years. With a flux increase of a factor ˜13, this outburst alone would have flagged Mrk 1018 as a changing-look AGN in photometric searches. The outburst is asymmetric in the u'-band with a rise of ˜100 days and a decline of ˜200 days. It was confirmed by the ATLAS forced photometry server. Using both STELLA and ATLAS, we compared the outburst as seen in three optical wavebands. We also followed up with an extensive multi-wavelength dataset in X-ray, UV, optical and infrared to compare the AGN components before and after outburst. Optical spectra were taken approximately one year before and after the outburst and showed no change. X-ray and UV observations were taken 6 - 7 months before and after. The primary X-ray flux returned to the state before the outburst but the 6.4 keV iron line increased in strength and UV emission was also increased. The IR light curve responded to the optical outburst extremely quickly. The optical light decay is best described by a linear decline, indicating that the increase was not caused by a tidal disruption event of a star. I will summarise a recently submitted paper on this outburst in 2020, including speculation as to why why Mrk 1018 changes its energy output repeatedly and in such a drastic manner.

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Presenter(s) : BROGAN, Roisin (Leibniz Institute for Astrophysics Potsdam)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **40** Type : **Invited talk**

Review: Optical Variability of AGN with SF and PSD

Tuesday, 27 June 2023 17:00 (30)

I will briefly review basic analysis methods used to describe the typical optical variability of AGN - structure functions and power spectra. I will discuss the applicability, usage, biases, and limitations of these methods and present some of the results for the OGLE AGN 20-year-long sample.

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Presenter(s) : KOZLOWSKI, Szymon (Warsaw University, Poland)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **41** Type : **Contributed talk**

Simultaneous observations of radio and X-ray variability in radio-quiet Seyfert galaxies

Tuesday, 27 June 2023 12:30 (15)

Radio variability in some radio-quiet (RQ) active galactic nuclei suggests emission from regions close to the central engine, possibly the outer accretion disc corona. If the origins of the radio and the X-ray emission are physically related, their emission may be temporarily correlated, possibly with some time delays. We present the results of quasi-simultaneous radio and X-ray monitoring of three RQ Seyfert galaxies, Mrk 110, Mrk 766, and NGC 4593, carried out with the Very Large Array at 8.5 GHz over a period of about 300 days, and with the Rossi X-ray Timing Explorer at 2-10 keV over a period of about 2000 days. The radio core variability is likely detected in the highest resolution (A configuration) observations of Mrk 110 and NGC 4593, with a fractional variability amplitude of 6.3% and 9.5%, respectively. A cross-correlation analysis suggests an apparently strong (Pearson $r = -0.89$) and highly significant correlation ($p = 1 \times 10^{-6}$) in Mrk 110, with the radio lagging the X-ray by 56 days. However, a further analysis of the r values distribution for physically unrelated long time delays, reveals that this correlation is not significant. This occurs since the Pearson correlation assumes white noise, while both the X-ray and the radio light curves follow red noise, which dramatically increases the chance, by a factor of $\sim 10^3$, to get extremely high r values in uncorrelated data sets. A significantly longer radio monitoring with a higher sampling rate, preferably with a high-resolution fixed radio array, is required in order to reliably detect a delay.

Primary author(s) : CHEN, Sina (Technion); LAOR, Ari (Technion); Prof. BEHAR, Ehud (Technion)

Presenter(s) : CHEN, Sina (Technion)

Session Classification : Accretion and variability theory

Contribution ID : **44** Type : **Contributed talk**

AGN Continuum Reverberation Mapping

Monday, 26 June 2023 11:00 (15)

Reverberation mapping (RM) is a powerful tool to explore the unresolved central region of active galactic nucleus (AGN), e.g., accretion disk. Determining the structure of accretion disks in AGN is fundamental to understanding the growth of supermassive black holes, confirming the standard thin disk theory, and examining the X-ray reprocessing variability model. However, recent continuum RM suggests that the observed accretion disk size is around three times larger than prediction. In this talk, I will introduce our recent continuum RM results of bright AGNs in ZTF and the well-known dwarf galaxy NGC 4395. We found that the continuum lag is dominated by the diffuse continuum emission, which may account for the disk-size discrepancy. In addition, we will introduce a new method to measure the reverberation black hole mass via continuum RM.

Primary author(s) : GUO, Hengxiao

Co-author(s) : Prof. BARTH, Aaron; Dr. WANG, Shu

Presenter(s) : GUO, Hengxiao

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **45** Type : **Contributed talk**

Candidate sub-kpc dual SMBHs revealed with variability-induced jitters of quasars

Thursday, 29 June 2023 17:45 (15)

Dual super massive black holes at sub-kpc to kpc scales are the products of galaxy mergers and the progenitors of eventually coalescing binary SMBHs. Dual AGNs or off-nucleus AGNs may be witnessed if both or one of the dual SMBHs are accreting. Despite its rarity, such systems are essential for learning the dynamical evolution of binary SMBHs as well as the process of galaxy merging. Recently a novel and highly efficient astrometry-based method named varstrometry has been put forward to search for dual SMBHs at high redshift. This method shows that the unsynchronized flux variability of off-nucleus and dual AGNs will cause astrometric jitter detectable by Gaia without spatially resolving them. Based on varstrometry we select a rare sample of 5 high redshift radio quasars with clear Gaia astrometric jitters, and with e-MERLIN observations a single compact radio source is revealed for each of them. Clear Gaia-radio offsets of $\sim 9-60$ mas are deteced in all but one targets. The observed Gaia jitters appear consistent with the expected values. These detected Gaia-radio offsets suggest these candidate dual SMBHs may have projected separations as small as ~ 0.01 - $0.1''$ (~ 0.1 kpc, depending on the optical flux ratio of two SMBHs).

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Presenter(s) : WANG, Haochen (University of Science and Technology of China)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **46** Type : **Contributed talk**

Modelling thermal reverberation in active galactic nuclei

Monday, 26 June 2023 12:45 (15)

Several active galactic nuclei (AGN) show UV/optical variability lagging behind the X-ray emission by a few days. The simplest and most straightforward interpretation is that the variable X-ray flux from the corona illuminates the accretion disc below where it is partially reflected and observed as fast X-ray reverberation signal, and partially absorbed and thermalised in the disc, which produces a slow UV and optical reverberation signal. Since the corona is thought to be centrally located and very small compared to the accretion disc, it first illuminates the hottest inner parts of the accretion disc and later on its colder further out areas. Thus one expects to see the original X-ray fluctuations to be firstly followed by variations in the UV and then in the optical wavebands.

In this talk, I will present our newly developed full GR-ray-tracing code that computes the thermally reverberated UV/optical continuum responding to X-ray illumination by a compact corona. Our code considers the mutual interaction of the accretion disc and the X–ray corona. I will discuss how the properties of the system (e.g., black hole spin, accretion rate, corona height, etc.) affect the UV/optical time lags. I will also present our results from modelling the observed lags obtained from long monitoring of bright local AGN.

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Presenter(s) : KAMMOUN, Elias (IRAP - CNRS)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **47** Type : **Poster**

Multi-wavelength study of extragalactic transients detected with eROSITA: A flaring event in an AGN

Several studies of actively accreting supermassive black holes have revealed that large amplitude variability often triggers significant spectral changes; a phenomenon known as changing look AGN (CLAGN). eROSITA through its successive all sky surveys, has made the detection of the sources using the X-ray band much more systematic. In 2020, eROSITA along with the Zwicky Transient Facility(ZTF) detected a flaring event in a type-1.9 AGN, where a sharp change of ~ 0.55 and ~ 0.3 in g- and r-band magnitudes was seen in ~ 81 days. We performed an extensive multiband follow-up campaign on the object for two years. Immediate optical follow-up using the Keck telescope revealed the appearance of a double-peaked Hβ emission line (previously absent in a 2005 6dF archival spectrum) and a bluer continuum compared to 2005, confirming a CLAGN event. The X-ray light curve exhibits an extreme flux variation. The X-ray spectral photon index is typical for AGN accretion. The long-term X-ray and optical light curves reveal a weaker second flare during early 2020. More optical spectroscopic follow-up shows that integrated flux of the Broad emission lines of Hβ and Hα tracks the X-ray–UV–Optical continuum. The infrared emission also responds to the transient variability. This transient event with multiwavelength signature is a sudden, temporary rise in accretion rate over a persistent, low accretion flow, e.g., speculatively caused by an accretion disk instability.

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Session Classification : Poster

Contribution ID : **48** Type : **Poster**

The multi-wavelength spectral evolution of NGC 1566 during its transient event in 2018

The variability of active galactic nuclei (AGN) across all wavelength bands is considered to be one of their most defining characteristics. Generally, their variability is assumed to be of stochastic nature and has been used with great success in the last 30 years to identify and map the innermost AGN structures – namely the broad-line region (BLR) and accretion disk (AD) – using methods such as reverberation mapping. In addition to the overall stochastic variability behavior of AGN, transient events such as changing-look (CL) transitions have gained more and more attention in recent years. In the optical domain, CL AGN are characterized by their change of spectral classification, switching between Sy 1 and Sy 2 and associated sub-types. These transitions happen on the order of months to years and are often accompanied by significant flux changes on the order of several magnitudes. Regarding the apparent changes in BLR kinematics and the huge flux change on relatively small time scales, CL events in AGN pose considerable challenges in understanding accretion onto supermassive black holes (SMBHs). For example, the typical transition time-scales cannot be explained by viscous radial inflow. Currently, several explanations for the CL phenomenon are discussed, including tidal disruption events (TDEs), microlensing caused by an intervening object, sudden changes of obscuration, or accretion disk instabilities

To date, a few dozen CL AGN have been identified, but only a few of them – most notably 1ES 1927+654 – have been studied spectroscopically in greater detail in temporal proximity to the transient event. This lack of high-quality data significantly complicates the understanding of the CL phenomenon. Here, we present results of a multi-wavelength campaign of NGC 1566 obtained with XMM-Newton, NuSTAR, Swift, and SALT. NGC 1566 is a local face-on Seyfert galaxy and is known for exhibiting recurrent outbursts. The flux and spectral variations in 2018 were the strongest changes observed since 1966, when NGC 1566 exhibited similarly strong broad-line emission. We obtained spectroscopic and photometric observations directly before, after, and during the transient event in 2018, in detail revealing changes in the BLR and the non-stellar continuum. We will discuss the emergence and evolution of line species not present in the low state, the evolution of the BLR, in particular variations in the line profiles and BLR kinematics, the nature of the non-stellar continuum, and the spectral energy distribution (SED) during the event. The results will be reviewed in context of currently discussed explanations for the CL phenomenon.

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Session Classification : Poster

Contribution ID : **50** Type : **Invited talk**

Review: X-ray variability of AGN

Monday, 26 June 2023 15:45 (30)

Supermassive black holes preserve information on the growth of the host galaxy and its dynamic evolution. Thus, constraining their parameters is crucial to shed light on their formation and evolution. In recent years, X-ray astronomy has undergone a renaissance, with several instruments that perform large observational campaigns and cover an extremely wide range of energy timescales to study Active Galactic Nuclei (AGN). The X-ray radiation produced by the closest accreting matter to the black hole shows distortions due to the strong relativistic effects. Proper modeling of these features constrains the system geometry and the interplay between the corona and the accretion disk. I will review the recent results of X-ray spectral timing analyses with an emphasis on the interpretation of the observations.

Primary author(s) : Dr. MASTROSERIO, Guglielmo

Presenter(s) : Dr. MASTROSERIO, Guglielmo

Session Classification : X-ray continuum variability

Contribution ID : **51** Type : **Poster**

Investigating optical variability in NLS1 galaxies with extreme radio features

A few decades have passed since the identification of narrow-line Seyfert 1 (NLS1) galaxies as a subclass of active galactic nuclei (AGN). NLS1s show a Seyfert 1-like spectrum, but with emission line widths similar to those of Seyfert 2 spectra. Such features are often believed to be produced by a high accretion rate, close to the Eddington limit, coupled with a low-mass black hole ($< 10^8 M_\odot$). Although few compared to the non-jetted sources, also jetted NLS1s have been discovered. By means of targeted observations of radio-quiet and -silent jetted NLS1s, seven sources with an inverted radio spectrum and extreme radio variability were identified. They show rapid high-frequency (37 GHz) flares that increase their flux density up to 9000-fold (Jy level). On the other hand, at low frequency (<9 GHz) and in the low state, they only reach flux densities up to mJy levels. Such behaviour may be produced by absorption of the jet emission, via synchrotron self-absorption or free-free absorption. These objects are known as absorbed jets (AJs). Until now, the only common feature that characterises all AJs is their radio spectra. I will present the results of a multi-epoch analysis, devoted to searching optical variability in AJs, using data retrieved from public surveys. For this purpose I performed light curve fitting following different approaches, such as Fourier and Wavelet analysis, and chi-square minimisation techniques, to find any similarity between the AJs. Moreover, a long-term comparison between radio and optical light curves has been carried out, investigating if the optical emitting regions are connected with those generating radio variability. Such strong radio variability had never been observed before in any AGN, making this work an important key to understanding the AJ phenomenon. Furthermore, understanding the physics behind this peculiar phenomenon may ultimately help us reveal a new and unexplored population of jetted AGN.

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Presenter(s) : CREPALDI, Luca (Università di Padova)

Session Classification : Poster

Contribution ID : **52** Type : **Contributed talk**

X-ray variability properties of the BASS unobscured AGN from XMM-Newton observations.

Monday, 26 June 2023 17:45 (15)

I will present the analysis of the X-ray variability properties of the Seyfert 1 Galaxies belonging to the BAT AGN Spectroscopic Survey (BASS) using XMM-Newton observations. This sample includes more than 500 observations of 151 local AGN (medium redshift z=0.06). The aim of this work is to constrain the relation between the common estimators of the variability amplitude (i.e., fractional variability and normalised excess variance), calculated in different energy bands, with the physical and accretion properties of AGN such as the black hole masses of the central supermassive black hole (known for all the sources of the BASS sample from either broad Balmer lines or reverberation mapping estimations) and Eddington ratios (estimated combining the black hole masses measurements with the estimates of the bolometric luminosity derived from the BAT 14-150 keV luminosity). As expected from previous studies we find a strong anti-correlation between the excess variance and the black hole mass. We do not find correlation between the excess variance and the Eddington ratio but we find a strong anti-correlation with the 2-10 keV luminosity, which disappears when we removed the dependence of the excess variance on the black hole mass. Exploring the relation of excess variance in different energy bands we found that the variability of the sources of our sample is mostly due to the flux variation of the primary continuum and/or of the reflection component, at least on scale of 10ks. I will also show the comparison of the variability property of the unobscured AGN of the BASS sample with the X-ray variability properties of a sample of 5 Super and Hyper-Eddington sources ($1< \lambda_{Edd} <426$) belonging to the Super-Eddington Accreting Massive Black Holes sample.

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Presenter(s) : Dr. TORTOSA, Alessia (Instituto de Estudios Astrofísicos, Facultad de Ingeniería y Ciencias, Universidad Diego Portales)

Session Classification : X-ray continuum variability

Contribution ID : **54** Type : **Contributed talk**

Exploring the jet-BLR connection: flare-induced variability in the optical emission lines

Tuesday, 27 June 2023 11:00 (15)

PKS 2004-447 is a narrow-line Seyfert 1 (NLS1) galaxy harboring relativistic jets capable of producing gamma-ray emission. On 2019-10-25, the Fermi Satellite detected a gamma-ray flare from this source for the first time. Thanks to coordinated spectral observations, we had a unique opportunity to study the behavior of the broad-line region (BLR) during a jet flare and searching for optical variability. Despite the obvious importance of understanding whether the jet can interact with the BLR, this aspect has not been thoroughly investigated. In my talk, I will introduce the peculiar nature of PKS 2004-447, which has remained poorly understood since its identification more than twenty years ago. I will also report on the results of our FORS2 and X-Shooter observations carried out before, during, and after the flare. During the high-energy event, a flux excess redshifted by 250 km/s is clearly seen in the Balmer, Paschen, and He I permitted lines. Such behavior has never been observed before, and interestingly this new emission feature is no longer visible 1.5 years after the flare, indicating a possible causal connection with the gamma-ray flare. The emission lines coming from the same atomic transition series show a similar velocity offset for this “red excess”, but the offset changes for different line series. This discovery suggests that the relativistic jet can affect the physics of the BLR in this peculiar AGN, and that flaring activity can lead to the formation of additional and localized broad emission components. Our results highlight the importance of optical spectroscopy for flaring jetted AGN, and that our understanding of the jet-BLR connection is still very limited. These results will be used as a starting point for future dedicated studies of this kind.

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Presenter(s) : Dr. BERTON, Marco (European Southern Observatory (ESO))

Session Classification : Emission Line variability

Contribution ID : **55** Type : **Contributed talk**

Exploring black hole scaling relations via the ensemble variability of active galactic nuclei

Monday, 26 June 2023 17:30 (15)

One of the most influential relations in extragalactic astrophysics is the one that links the stellar-mass component of galaxies (Mstar) to the masses of the supermassive black holes (MBH) at their centres. Observational constraints on the shape, normalisation and redshift evolution of the Mstar-MBH relation provide important clues on the co-evolution of galaxies and their supermassive black-holes. Unfortunately, measuring the Mstar-MBH relation, particularly at higher redshifts, is challenging and prone to systemics. In this contribution I will present a new method that provides a handle on the Mstar-MBH relation by modelling the ensemble variability of X-ray selected AGN samples. A key ingredient of the method is the modelling strategy that links, for the first time, the demographics of AGN to the physics of the stochastic flux variations of accretion flows and allows the interpretation of the variability properties of AGN populations. I will demonstrate the predictive power of the model by comparing in a forward manner with observational measurements of the ensemble excess variance of X-ray AGN in the Chandra Deep Field South. I will also discuss future prospects for joint constraints on both models of AGN variability and the Mstar-MBH relation as a function of redshift.

Primary author(s) : Dr. GEORGAKAKIS, Antonis (NOA); Prof. PAPADAKIS, Iossif (University of Crete); Prof. PAOLILLO, Maurizio (Naples)

Presenter(s) : Dr. GEORGAKAKIS, Antonis (NOA)

Session Classification : X-ray continuum variability

Contribution ID : **56** Type : **Contributed talk**

Detecting AGN flares using Gaussian Processes

Friday, 30 June 2023 18:00 (15)

Active galactic nuclei (AGN) exhibit small amplitude, short timescale variability in their optical luminosities, of roughly a few tenths of a magnitude over periods of hours to years. But extreme variability of AGN - large luminosity changes that are a significant departure from the baseline variability - are known as AGN flares. These events are rare and their timescales poorly constrained, and most of the literature focuses on individual events. With surveys such as the Legacy Survey of Space and Time (LSST) promising millions of transient detections per night in the coming decade, there is a need for fast and efficient classification of AGN flares. The problem with the systematic detection of AGN flares is the ability to detect them against a variable baseline; the ability to define a signal as a significant departure from the ever-present variability is a statistical challenge. Recently, Gaussian Processes (GPs) have revolutionised the analysis of time-series data in many areas of astronomical research. However, they have seen limited uptake within AGN astronomy. Here we investigate the efficacy of Gaussian Processes to detect AGN flares in both simulated and real optical light curves. We show that a GP can successfully detect AGN flares with a false-positive rate of less than one per cent, and we present examples of AGN that show extreme variability.

Primary author(s) : MCLAUGHLIN, Summer (University of Sheffield); Mr. MULLANEY, James (University of Sheffield)

Presenter(s) : MCLAUGHLIN, Summer (University of Sheffield)

Session Classification : Methods and techniques

Contribution ID : **57** Type : **Invited talk**

Review: AGN accretion disk physics and variability

Tuesday, 27 June 2023 11:45 (30)

Traditional accretion disk models have always had problems explaining a variety of observed features of AGN, particularly the short wavelength SED in the ultraviolet and beyond, and the rapid variability. I will review possible resolutions to these problems, including the effects of outflows, opacity-driven convection in the disk, and magnetically elevated disks.

Primary author(s) : BLAES, Omer (University of California, Santa Barbara)

Presenter(s) : BLAES, Omer (University of California, Santa Barbara)

Session Classification : Accretion and variability theory

Contribution ID : **59** Type : **Contributed talk**

eROSITA Detection of Cloud Occultation Events in Seyfert AGN, and Contributions for Clumpy-Torus models

Wednesday, 28 June 2023 12:45 (15)

Recent years have seen broad observational support for the circumnuclear gas around supermassive black holes to contain a clumpy component. In the X-ray band, individual clouds can manifest themselves when they transit the line of sight to the X-ray corona, temporarily obscuring the X-ray continuum, and indicating the characteristics and location of these clouds.

The eROSITA X-ray telescope aboard Spectrum X/Gamma is performing multiple all-sky X-ray surveys, including monitoring a vast sample of AGN and galaxies. Such monitoring can amplify rare cloud occultation events, allowing us to accumulate observational constraints for clumpy-torus models, including cloud distribution and composition parameters.

Here, we discuss the first cloud occultation events detected in a Seyfert 1 galaxy by eROSITA: in this Seyfert, the soft X-ray flux dipped abruptly for $\sim$ 10-18 months during 2020-2021, recovered, but then dropped a second time by Spring 2022. Our two-year multi-wavelength follow-up campaign included X-ray/UV and ground-based optical photometric and spectroscopic observations, and confirmed that the soft X-ray flux dips were caused by partial-covering obscuration by two separate, single compact clouds near the black hole. The two transiting clouds are consistent with neutral or lowly-ionized gas, residing at radial distances commensurate with the optical Broad Line Region and the inner dusty torus, respectively.

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Presenter(s) : MARKOWITZ, Alex (Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences)

Session Classification : Current and Future Surveys

Contribution ID : **60** Type : **Contributed talk**

Looking beyond the lamppost: a new method of understanding AGN continuum variability

Monday, 26 June 2023 12:15 (15)

The variability of Active Galactic Nuclei (AGNs) has been studied for decades, with the UV/optical continuum observed to stochastically fluctuate at the 10% level over timescales of weeks to months. Fundamentally, this variability should be driven by temperature fluctuations in the accretion disc surrounding the central black hole. Where multiband lightcurves are available, the variability is similar in all bands, but the bluer wavelengths vary earlier than the redder wavelengths with delays typical of the light travel time across the disc. These observations have led to the commonly used "lamppost" model, where central luminosity fluctuations - typically linked with X-ray emission - irradiate the disc to drive the UV/optical variability. However, it seems unlikely that this is the only source of variability in the disc. We introduce a new approach to understanding disc variability where we invert the multiband UV/optical lightcurves of AGNs into "maps" of the disc resolved in time and in radius under the assumption of axisymmetry. In addition to a lamppost "signal", we see strong evidence for small amplitude, slow-moving temperature fluctuations. We suggest that these fluctuations dominate AGN variability on long timescales, a hypothesis that will be tested by Rubin/LSST in the near future. This new method for understanding disc variability can also be used to probe other issues, such as the degree to which unrecognized emission from the broad line region (BLR) contaminates continuum lightcurves.

Primary author(s) : NEUSTADT, Jack (The Ohio State University)

Presenter(s) : NEUSTADT, Jack (The Ohio State University)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **61** Type : **Contributed talk**

On the coronal temperature and its variability

Monday, 26 June 2023 16:30 (15)

The hard X-ray emission universally found in AGN is believed to be produced in the so-called corona, of which the physical nature remains unclear. A fundamental parameter is the coronal temperature ($T_{\rm c}$), which could be measured by fitting the high-energy cutoff ($E_{\rm cut}$) in the hard X-ray spectra. With multiple NuSTAR observations, we search for the variation of $T_{\rm c}/E_{\rm cut}$ in individual sources. We get a small sample of several sources, which demonstrate an interesting non-monotonic variation pattern, with a break point of the photon index Γ detected. Sources are found to be "hotter-softer-when-brighter" at $\Gamma < 2.05$, but turn into "cooler-softer-when-brighter" at $\Gamma > 2.05$. Such a behavior indicates that multiple mechanisms, for instance, changes of the coronal geometry and the cooling efficiency, are contributing to the X-ray variability in AGN. Meanwhile, we are also interested in how $T_{\rm c}/E_{\rm cut}$ differs from one source to another. We measure the $T_{\rm c}/E_{\rm cut}$ in a large sample and investigate the correlations between $T_{\rm c}$ and other parameters (photon index Γ and Eddington ratio). A strong positive correlation between $T_{\rm c}$ and Γ is detected, while none between $T_{\rm c}$ and Eddington ratio. In other words, counter-intuitively, hotter coronae tend to produce softer spectra, while the accretion rate is not a primary determinant of the coronal temperature.

Primary author(s) : Mr. KANG, Jia-Lai (University of Science and Technology of China); Prof. WANG, Jun-Xian (University of Science and Technology of China)

Presenter(s) : Mr. KANG, Jia-Lai (University of Science and Technology of China)

Session Classification : X-ray continuum variability

Contribution ID : **62** Type : **Poster**

Exploring AGN variability in the hardest X-rays with NuSTAR

We present here the study of the hot comptonising corona in AGN through a spectroscopic and variability analysis in the hard X-ray band (3-79 keV) with NuSTAR. We studied a flux-limited sample of 21 AGN, we investigated their coronal physical properties, such as temperature and optical depth, and their dependence from the black hole mass and the Eddington ratio, considering two possible geometries. Using NuSTAR light curves we explored the AGN variability on time scales from 1ks to 10ks, by means of the excess variance evaluated in different energy bands. This study allowed us to explore the X-ray variability of AGN through NuSTAR hard X-ray light curves, and for the first time the relationship between the variability and the coronal parameters. Finally we show how spectro-polarimetry measurements available with the proposed mission enhanced X-ray Timing and Polarimetry mission (eXTP) will shed light on the geometry of AGN coronae.

Primary author(s) : SERAFINELLI, Roberto (INAF-IAPS)

Presenter(s) : SERAFINELLI, Roberto (INAF-IAPS)

Session Classification : Poster

Contribution ID : **63** Type : **Poster**

Covering Factor in AGNs: Evolution or Selection?

Recent studies have reported on a possible evolution of the covering factor (CF) with redshift. The goal of the presentation is to answer the question if this evolution is real or whether selection effects play an important role. The presented analysis was based on cross-matched multiwavelength photometrical data from the five major surveys (SDSS, GALEX, UKIDSS, WISE, Spitzer). A sample of over 17,000 quasars was derived, and separated into two redshift bins – low-z and high-z. The data were further divided into smaller subsets based on the data quality. CF estimation used in our work was calculated from the ratio between dusty torus infrared luminosity (L[ir]) and the accretion disk optical luminosity (L[agn]), as it was postulated in the literature. We found that the accuracy of the WISE W4 filter is problematic and, whenever possible, Spitzer MIPS 24 um should be used instead. This allowed us to reduce bias especially in the more distance sources. Luminosity evolution with redshift for both L[ir] and L[agn] was confirmed with the Efron&Petrosian test. The low-z and high-z samples follow, however, a similar correlation between L[agn] and L[ir]. The relation between L[ir]and L[agn] is slightly different than the 1:1 scaling, hinting for a more complex relationship between CF and L[agn], affected by possible contaminations. The individual components (stellar, dust and AGN among others) of spectral energy distribution (SED) were separated by SED fitting with the CIGALE code. The AGN emission was fitted with the SKIRTOR model. The SED fitting, enabled us to study possible contaminations in more detail, while also ensuring the alternative method for L[ir] and L[agn] estimations.

No evolution of the CF is detected based on the subsample within the high SMBH mass bin, or with high luminosities: the low-z and high-z values of our CF estimator are found to have the same distribution.

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Presenter(s) : RAŁOWSKI, Mateusz (Jagiellonian University)

Session Classification : Poster

Contribution ID : **64** Type : **Invited talk**

Review: Multiwavelength variability of radio-loud AGN/blazars

Friday, 30 June 2023 11:30 (30)

Radio-loud AGN are characterized by plasma jets that are formidable particle accelerators. In blazars we observe jets at a small angle with respect to the line of sight, with consequent relativistic Doppler beaming of the jet radiation. Therefore, the extremely variable jet emission dominates the spectral energy distribution of blazars from the radio band up to the gamma rays. I will review the main results obtained through the analysis and interpretation of the multiwavelength variability of radio-loud AGN, focussing on blazars.

Primary author(s) : Dr. RAITERI, Claudia M. (INAF-Osservatorio Astrofisico di Torino)

Presenter(s) : Dr. RAITERI, Claudia M. (INAF-Osservatorio Astrofisico di Torino)

Session Classification : Radio loud AGN

Contribution ID : **65** Type : **Contributed talk**

The search for variable AGN with Gaia

Wednesday, 28 June 2023 10:45 (15)

The third release of Gaia data, published on June 13, 2022, includes not only astrometric and astrophysical parameters of different types of sources, but also several catalogues of variable sources. Among these, the catalogue of Gaia variable AGN, which is described by Carnerero et al. (2022). To identify the variable AGN, we analyzed the light curves of more than 80 million sources observed by Gaia, selecting 870 thousands of them compliant with requirements on their variability properties (structure function, Butler and Bloom metrics, fractional variability), color indices, astrometric parameters and others. The purpose was to create a variable AGN catalogue as pure as possible. More than 21,000 of these 870 thousand sources are identified as variable AGN for the first time. For each source of the catalogue, the Gaia multi-band light curves and the values of a number of variability parameters have been included in the database. In view of the next Gaia DR4, we are now implementing new variability parameters that will be published in the Gaia AGN variability table. They will be useful to the community, both for carrying out statistical studies and for AGN classification with machine learning.

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Presenter(s) : CARNERERO MARTIN, Maria Isabel (INAF-Osservatorio Astrofisico di Torino)

Session Classification : Current and Future Surveys

Contribution ID : **67** Type : **Poster**

Quasar accretion disk variability using multi-epoch SDSS-V UV-optical spectroscopic

Quasars (QSO) are variable sources in all wavelengths and in all time scales. Here we study the variability of the QSO accretion disk continuum emission using the new multi-epoch SDSS-V spectroscopic data in timescales of days to months. We use a spectral decomposition method to measure the disk emission and the high cadence spectral data to characterize the disk variability as a function of a power law slope differences and the power law flux differences of consecutive observations and in different line-free emission wavelength bands. Results show that the disk emission is steeper when the flux increases if we measure at UV-wavelengths and the disk emission has a flatten profile if the flux increases when tested in redder wavelengths.

Primary author(s) : BERNAL, Santiago (Instituto de Física y Astronomía, Universidad de Valparaíso); Prof. ARÉVALO, Patricia (Instituto de Física y Astronomía, Universidad de Valparaíso)

Presenter(s) : BERNAL, Santiago (Instituto de Física y Astronomía, Universidad de Valparaíso)

Session Classification : Poster

Contribution ID : **68** Type : **Contributed talk**

Inferring long-term variability on scales of 10^4-5 yrs using extended emission line regions

Tuesday, 27 June 2023 10:45 (15)

We present the analysis of a five nearby AGN that present extended emission line regions (EELRs) observed with the VLT/MUSE spectrograph. Spatially resolved emission line diagnostics indicate that the EELRs have been primarily photo-ionized by their AGN. The stellar and gas component kinematics indicate past merger or galaxy interactions that have perturbed all of these sources. We generate sets of photo-ionization models and fit these to different regions along the different EELRs, covering distances of tens of kpc from the centre. These models allow us to estimate the bolometric luminosity required at different radii to excite the gas at the observed state. Our results suggests a systematic gradual decrease in AGN luminosity, and hence the accretion rate onto the SMBH, by a factor ~ 100 over the past ~ 10^4 yr for every galaxy in the sample. This allow us to probe AGN variability on scales larger than possible for human timescales.

Primary author(s) : FINLEZ, Carolina

Presenter(s) : FINLEZ, Carolina

Session Classification : Emission Line variability

Contribution ID : **69** Type : **Contributed talk**

A Decade of Near-Infrared Variability in NGC4388: Insights into the AGN Structure

Tuesday, 27 June 2023 17:30 (15)

Variability studies of Active Galactic Nuclei (AGNs) have proven to be a powerful diagnostic tool for understanding the physics and properties of these objects. They provide insights into the spatial and temporal distribution of the emitting regions, the structure and dynamics of the accretion disk, and the properties of the central black hole. Here, we present the results of a ten-year campaign to monitor the near-infrared emission of the Seyfert 1.9/2 nucleus of NGC4388, covering J and K band spectroscopy. During this period, the hot dust continuum of the nucleus of this object varied by up to 200% under certain wavelength ranges. However, emission lines of low and medium ionization did not change beyond our error margin, whereas we detected variations of almost 100% at the [Ca_{VIII}] coronal line. These results suggest that between 2011 and 2013, we were able to access an unresolved nuclear region that became obscured after 2015. We also mapped continuum and emission lines beyond the nucleus and found no significant variation within this time frame. These maps also indicate that emission lines are distributed along two main directions, representing the disc and the radio jet. Furthermore, the ionization of the emission lines is compatible with photoionization by an AGN in our whole 8x8 arcsec^2 field of view. Lastly, we detected a strong decrease in dust reddening along the radio jet, suggesting that the AGN is destroying dust grains in this region.

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Presenter(s) : DAHMER HAHN, Luis Gabriel (Shanghai Astronomical Observatory)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **71** Type : **Contributed talk**

Revealing Changing-Look Quasar Candidates in SDSS Stripe 82 with SDSS, Pan-STARRS1, and ZTF data.

Tuesday, 27 June 2023 17:45 (15)

We use data from the Panoramic Survey Telescope and Rapid Response System 1 Survey (Pan-STARRS1, PS1) to extend the Sloan Digital Sky Survey (SDSS) Stripe 82 quasar light curves. Combining PS1 and SDSS light curves provides a 15 yr baseline for 9248 quasars–five years longer than prior studies that used only SDSS. We fit the light curves with the damped random walk (DRW) model – a statistical description of their variability. We correlate the resulting DRW model parameters (asymptotic variability amplitude, and characteristic timescale), with quasar physical properties (black hole mass, bolometric luminosity, and redshift). We also make predictions for the fidelity of DRW model parameter retrieval when light curves will be further extended with Zwicky Transient Facility (ZTF) and the Rubin Observatory Legacy Survey of Space and Time (LSST) data. Finally, we show how updated DRW parameters offer an independent method of discovering changing-look quasar candidates (CLQSOs). The candidates are outliers in terms of differences in magnitude, and scatter between SDSS and PS1 segments. We identify 40 objects (35 newly reported) exhibiting a tenfold increase in variability timescale between SDSS and SDSS - PS1 data. An accompanying large (over 0.5 mag) change in brightness is characteristic of CLQSOs. We summarize the results of a recent program of spectroscopic follow-up of select CLQSO candidates carried out at the Apache Point Observatory.

Primary author(s) : SUBERLAK, Krzysztof (University of Washington); Dr. IVEZIC, Zeljko (University of Washington); Dr. MACLEOD, Chelsea (Harvard University)

Presenter(s) : SUBERLAK, Krzysztof (University of Washington)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **74** Type : **Poster**

The disk reverberation mapping of X-ray weak quasar SDSS J153913.47+395423.4.

The variable UV/optical emission results from the accretion disk reprocessing of the highly fluctuating X-ray emission. This can be tested by measuring inter-band time lags of quasars with different X-ray power. We report the inter-band time lag in an X-ray weak quasar, SDSS J153913.47+395423.4. We found a significant cross-correlation with a time delay of 32 days (observed-frame) detected in the Zwicky Transient Facility g and r light curves. During the talk, we will examine the required X-ray power in regard to the observed one and discuss its implications on the origin of quasar multi-band variability.

Primary author(s) : MARCULEWICZ, Marcin (Xiamen University); SUN, Mouyuan

Presenter(s) : MARCULEWICZ, Marcin (Xiamen University)

Session Classification : Poster

Contribution ID : **75** Type : **Contributed talk**

Investigating the high-luminosity end of the H beta size-luminosity relation based on the 6-year Seoul National University Monitoring Project (SAMP)

Tuesday, 27 June 2023 10:15 (15)

Reverberation mapping (RM) of Active Galactic Nuclei (AGNs) is the primary method to measure AGN broad line region (BLR) sizes and black hole (BH) masses. Most objects in the current Hβ RM sample are low-to-intermediate luminosity AGNs with only a few objects having $L_{5100} \geq 10^{44.5}$ erg/s. Here we present the latest results from our 6-year Seoul National University AGN Monitoring Project (SAMP). With hundreds of nights of regularly sampled spectroscopic/photometric observations, we successfully obtain reliable Hβ lags and BH masses for 24 objects in the luminosity range of $L_{5100} = 10^{44.1\sim45.6}$ erg/s. The BLR sizes of these objects are generally smaller than the expectation from Bentz et al. relation. By applying an uniform lag analysis to literature Hβ RM light curves and selecting reliable lag measurements to combine with SAMP measurements, we find the current Hβ size-luminosity relation has a slope of 0.41 ± 0.02 with an intrinsic scatter of 0.19 dex. We confirm that the accretion rate / UV-optical spectral energy distribution is related to this shallower slope. In addition, we will present the Hβ velocity resolved lag measurements for $\sim$ 20 AGNs and discuss the implication of these results on the BLR properties.

Primary author(s) : WANG, Shu (Seoul National University); Dr. WOO, Jong-Hak (Seoul National University); SAMP COLLABORATION

Presenter(s) : WANG, Shu (Seoul National University)

Session Classification : Emission Line variability

Contribution ID : **76** Type : **Contributed talk**

The Ultraviolet/optical Variability and Its Implication for the Physical Processes in Quasars

Monday, 26 June 2023 10:45 (15)

Quasars are a class of objects in the Universe with very apparent flux variation. UV/optical variability of such sources has attracted particular attention. The radiation in this band is thought to come from the accretion disk. As the central dynamical region of a quasar, the accretion disk is theoretically believed to be related to structures such as the corona and emission line region. Studying the correlations between UV/optical variability and physical processes occurring in these structures can help to constrain and improve the relevant physical models.

We make a one-parameter characterization of UV/optical variability amplitude of quasars using the famous Sloan Digital Sky Survey 10-year light curves in the Stripe 82 region, and explores the statistical correlations between AGN UV/optical variability (from the accretion disk) and X-ray emission (from corona), and between the variability and UV/optical line emission (from line emitting regions). We find that there is an intrinsic positive correlation between UV/optical variability and X-ray loudness, and this correlation occurs mainly at long timescales. This result prefers the physical picture depicted by the thermal fluctuation model of accretion disk, i.e., both the corona heating and UV/optical variability are related to magnetic turbulence in the accretion disk. Then we find a positive intrinsic correlation between the variability amplitude and the equivalent width for the broad Mg II line, the C IV line and the [O III] 5007 line. We point out that the possible physical reason behind such correlation could be: a more variable accretion disk will have a harder and bluer spectral energy distribution and therefore increases the emission line equivalent width; on the other hand, a more variable accretion disk may launch more clouds, thus increasing the covering factor of emission line region.

In the future, with the rapid progress of time-domain surveys, more extensive/systematical studies of AGN variability could significantly promote our understanding of AGN variability and relevant physical processes.

Primary author(s) : KANG, Wenyong (University of Science and Technology of China)

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Presenter(s) : KANG, Wenyong (University of Science and Technology of China)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **78** Type : **Invited talk**

Review: Reverberation Mapping of Emission Lines in AGNs: Last Decade and Future Prospects

Tuesday, 27 June 2023 09:30 (30)

Reverberation Mapping (RM) is a powerful technique for studying the geometry and kinematics of the broad-line regions in AGNs, as well as measuring the masses of supermassive black holes. This is achieved by observing the delayed response of broad emission lines with respect to the varying continuum. Significant progress has been made over the past decade, with the accumulation of RM data in different emission lines of various types of AGNs, as well as the development of more sophisticated analysis methods. In this talk, I will try to review the past 10 years of RM of emission lines in AGNs and discuss future prospects.

Primary author(s) : DU, Pu (Institute of High Energy Physics, Chinese Academy of Sciences)

Presenter(s) : DU, Pu (Institute of High Energy Physics, Chinese Academy of Sciences)

Session Classification : Emission Line variability

Contribution ID : **79** Type : **Poster**

The multi-wavelength monitoring campaign of the variable Seyfert NGC 2992

The near X-ray bright Seyfert 2 galaxy NGC 2992 was extensively observed by XMM-Newton, NuSTAR and Swift from 2019 to the end of 2021. The resulting exposures provide a compelling multi-epoch dataset to test for the properties of this source across different timescales, from hours up to years. Our analysis revealed the X-ray emission of NGC 2992 to show remarkable changes (larger than a factor of ˜10) with the fastest variability of ˜60% observed in few hours. However, these prominent variations are only accompanied by moderate changes of the spectral properties of the NGC 2992 spectrum at odds in principle with a variable hot corona. We will report on the spectral and temporal analyses that, chasing different timescales, provide a comprehensive and detailed description of the accretion mechanism in place in the nucleus of NGC 2992.

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Presenter(s) : MIDDEI, Riccardo (Space Science Data Center of the Italian Space Agency/ INAF -Osservatorio astronomico di Roma)

Session Classification : Poster

Contribution ID : **80** Type : **Poster**

Testing Super-Eddington Accretion onto a Supermassive Black Hole: Reverberation mapping of PG 1119+120

Accretion onto supermassive black holes (SMBHs) is known to take place through an optically thick geometrically thin accretion disk (Shakura & Sunyaev 1973) when accreting below the Eddington limit. Beyond this limit, the high radiation pressure increases the disk thickness close to the black hole (Abramowicz et al. 1988). Theoretically this results in a so-called 'slim' disk where photons are radially advected onto the black hole before they can escape. Understanding this process is particularly important considering the rapid growth of SMBH mass in the early universe. However, observational tests of the accretion disk in this regime are scarce.

As spatially resolving the accretion disk is unattainable, we rely on continuum reverberation mapping to exploit the intrinsic variability of the black hole and the finite travel time of light to dissect the accretion flow, providing a direct test of the accretion structure.

In the first part of the talk, I will discuss a new tool to model AGN lightcurves (PyROA , Donnan+21) to infer inter-lightcurve time delays, with advantages over other techniques. I will then summarise recent work of Donnan+23 applying this tool to test super-Eddington accretion onto the local quasar, PG 1119+120. From continuum monitoring over two years with the Las Cumbres Observatory and spectral monitoring from Calar Alto, we measure the black hole mass, test the temperature profile of the disk and model the AGN SED with theoretical models of a thin and slim accretion disk. We find the slim accretion model to be fully consistent with our data but we cannot rule out the thin disk scenario. We additionally detect diffuse continuum emission from the BLR acting on long timescales.

Primary author(s) : Mr. DONNAN, Fergus

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Presenter(s) : Mr. DONNAN, Fergus

Session Classification : Poster

Contribution ID : **81** Type : **Contributed talk**

Detection of Quasi-Periodic Eruptions in Extragalactic X-Ray Sources with Machine Learning

Friday, 30 June 2023 17:45 (15)

Quasi-periodic eruptions (QPEs) are a novel phenomenon in high-energy astrophysics, and to date have only been confirmed to be observed in a small number of AGN. Characterised by high amplitude variability over relatively short timescales, QPEs have the potential to provide insights into the strong gravity regimes in the innermost regions of the accretion disks around AGN. To provide robust predictions of the physical mechanisms involved we need to find more QPE sources to broaden the understanding of the parameter space they inhabit. We use known observations of QPEs and simulated lightcurves to determine whether machine learning approaches can detect QPE sources, and then apply these trained networks to the latest release of the XMM Serendipitous Source Catalogue in the hunt for further candidates.

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Presenter(s) : WEBBE, Robbie (University of Bristol)

Session Classification : Methods and techniques

Contribution ID : **82** Type : **Contributed talk**

Optical/X-ray variations of the changing-look AGN IRAS23226-3843

Thursday, 29 June 2023 10:45 (15)

We present spectroscopic and photometric observations of the changing look AGN IRAS23226-3843. This object has previously been classified as a changing-look AGN based on observations taken in the 1990s in comparison to X-ray data (Swift, XMM-Newton, and NuSTAR) and optical spectra taken after a very strong X-ray decline in 2017. In 2019, Swift observations revealed a strong rebrightening in X-ray and UV fluxes. We took follow-up X-ray observations of IRAS23226-3843 together with optical spectra from 2019 until 2021. IRAS23226-3843 showed a strong X-ray and optical outburst in 2019. It varied in the X-ray continuum by a factor of 5 and in the optical continuum by a factor of 1.6 within two months. The Balmer and FeII emission-line intensities showed comparable variability amplitudes during the outburst in 2019. The Halpha emission-line profiles of IRAS23226-3843 changed from a blue-peaked profile in the years 1997 and 1999 to a broad double-peaked profile in 2017 and 2019. However, there were no major profile variations in the extremely broad double-peaked profiles despite the strong intensity variations in 2019. One year after the outburst, IRAS23226-3843 changed its optical spectral type and became a Seyfert type 2 object in 2020. A deep broadband XMM/NuSTAR spectrum was taken during IRAS23226-3843 maximum state in 2019. This spectrum is qualitatively very similar to a spectrum taken in 2017, but by a factor of 10 higher. The soft X-ray band appears featureless. The soft excess is well modeled with a Comptonization model.

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Presenter(s) : KOLLATSCHNY, W.

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **84** Type : **Poster**

Unveiling the Connection between UV/Optical Variability and Physical Characteristics of X-ray-Selected Type 1 AGN

We present our results investigating the correlation between the variability of UV/optical light curves and the physical parameters for a sample of about 7500 AGN selected from the Spectroscopic IDentification of eROSITA Sources (SPIDERS) AGN catalog. To study the UV/optical variability, we use well-sampled g and r-band light curves obtained from the ZTF survey. We first calculate the fractional excess variance in the light curves and then model the light curves using a Damped Random Walk (DRW) process to extract the variability amplitudes and the damping timescales. Our results show that the variability amplitudes in the g and r bands are strongly correlated. We find a weak correlation between the damping amplitudes of the light curves and known physical parameters such as redshift, SMBH mass, luminosity, and Eddington ratio. Further, we also do not find a strong correlation between the damping timescale and the physical parameters, namely the luminosity, SMBH mass, and the Eddington ratio. We also generate the Power Spectrum Density (PSD) of these light curves to extract the relation between the PSD slopes and the above-mentioned physical parameters. Further study of the optical variability characteristics and their correlation with physical parameters will contribute to a better understanding of their relationship.

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Presenter(s) : Mr. JHA, Vivek (ARIES)

Session Classification : Poster

Contribution ID : **85** Type : **Contributed talk**

The optically elusive, changing look active nucleus in NGC4156

Thursday, 29 June 2023 16:00 (15)

Despite the increasing number of newly discovered changing look active galactic nuclei (AGN), larger samples of known objects and multi-epoch observations are needed to shed light on this debated physical mechanism. In this talk, I will report on the changing look AGN in the galaxy NGC4156, as serendipitously discovered thanks to data acquired in 2019 at the Telescopio Nazionale Galileo (TNG) during a student observing program. Unlike previous optical spectra showing no signatures of broad-line emission, our 2019 TNG data unexpectedly revealed the appearance of broad components in both Hα and Hβ profiles, along with a rising continuum, overall pointing to a transition from a type 2 towards a (nearly) type 1 AGN. The broad-line emission has been then confirmed by our 2022 TNG follow-up observations, whereas the rising continuum is no longer detected, which hints at a further evolution backwards to a (nearly) type 2. I will discuss possible mechanisms at the origin of the observed optical variability of NGC4156, and briefly compare it to what observed in its X-ray multi-epoch observations. Approved optical (Asiago telescope) and X-ray (Swift) monitoring programs will provide us further insights into the variability of this source, possibly constraining the typical timescales of these changing look events.

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Presenter(s) : TOZZI, Giulia (Università di Firenze)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **86** Type : **Poster**

Investigating high-$\lambda_{\rm Edd}$ accretion with X-HESS: a new XMM-Newton sample of serendipitous highly accreting AGN

The Eddington ratio $\lambda_{\rm Edd}\$, is the key parameter that describes the accretion mode of active galactic nuclei (AGN). Among the different modes, high-$\lambda_{\rm Edd}$ accretion is particularly fascinating because of its implications in the context of accretion physics, as well as AGN feedback. However, due to their relative paucity in the local Universe (z$<$0.1), only a limited number of AGN accreting in the high-$\lambda_{\rm Edd}$ regime can benefit of currently available dedicated observations, especially at higher z. To tackle this issue we exploit the vast database of XMM-Newton serendipitous observations to create a new, large sample of highly accreting AGN named as XMM-Newton High-Eddington Serendipitous AGN Sample (X-HESS). X-HESS includes 143 observations of 61 AGN, $\sim$40% of which disposing of multi-epoch observations, disclosing the unprecedented possibility to study not only the spectral but also variability features of high-$\lambda_{\rm Edd}$ AGN in much broader intervals of redshift, black hole mass, bolometric luminosity and $\lambda_{\rm Edd}$ with respect to the bulk of pre-existing AGN samples. Approximately two-thirds of the X-HESS observations are complemented with simultaneous OM measurements. Thanks to the high-quality XMM-Newton observations we probe a large variety of correlations between the X-ray spectral, variability, optical/UV and physical properties of high-$\lambda_{\rm Edd}$ AGN, extending the dynamical range of previously reported relations towards poorly explored intervals.

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Session Classification : Poster

Contribution ID : **87** Type : **Poster**

LSST AGN Data Challange database: clustering and variability analysis of quasar light curves

Here we study the variability of quasar light curves found in the LSST AGN Data Challenge (LSST_AGN_DC), a dataset compiled from various catalogs for testing key aspects of active galactic nuclei (AGN) science with the Rubin Observatory Legacy Survey of Space and Time (LSST). The distributions of quasar parameters in large databases may show bimodality or multimodality, thus as preprocessing step it is necessary to cluster light curves according to their local topology.

For clustering quasar light curves we applied Self-Organizing Map (SOM). These clustered light curves were analysed by standard and modified structure functions. Inferred variability properties were checked on modeled light curves using a conditional neural process.

We detected 36 clusters of quasar light curves, each containing light curves of specific topology. The structure function analysis showed that each cluster has specific variability characteristics. For example, we detected one cluster of 300 quasars with low-variable light curves, which could be consistent with microlensing events on a long temporal time scale. Importantly, modeling light curves with the conditional neural process does not alternate variability characteristics of light curves , and it can be a vital tool for studying large datasets containing a significant population of microlensed quasars.

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Session Classification : Poster

Contribution ID : **88** Type : **Contributed talk**

Long and short term, X-ray/optical/UV time-lags in AGN

Monday, 26 June 2023 12:00 (15)

Recent multi-wavelength surveys of a few AGN have given us the opportunity to constrain well the cross-correlation between the X-rays and the UV/optical variations in these objects. The variations in the UV lead the variations detected at longer wavelengths in almost all cases where good quality light curves, in many wavebands, exist. However, there have been indications that the optical variations lead the UV variations on the longest sampled time scales in a few objects. This could indicate the presence of accretion rate variations which propagate inwards. We use well sampled, long light curves of a few Seyfert galaxies to compute the time lags on both long and short time scales. We will present the results regarding the dependence of the observed time-lags on the probed time-scale, and we will discuss possible constraints on various models for the observed optical/UV variations in AGN.

Primary author(s) : PAPADAKIS, Iossif

Presenter(s) : PAPADAKIS, Iossif

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **90** Type : **Invited talk**

Review: AGN Selection and Characterization in Next-Generation Time-domain Surveys

Friday, 30 June 2023 17:00 (30)

The emerging all-sky multi-epoch surveys (e.g., ZTF, Rubin LSST) have started a new era of time-domain astronomy. The variable nature of AGN across all wavelengths presents us with unique opportunities to probe AGN physics via time-domain analysis. I will start this talk by reviewing the time-domain analysis techniques, traditional and machine-learning based, currently employed in AGN selection and characterization. Then, I will present our most recent work on modeling ˜30,000 quasar UV/optical light curves as second-order continuous-time autoregressive moving-average (CARMA) processes and introduce the new software package–EzTao–that we developed to conduct the modeling task. Lastly, I will preview our ongoing work to improve the current CARMA modeling technique and provide an outlook for further developments that will maximize the science output of next-generation time-domain surveys like the Rubin LSST.

Primary author(s) : YU, Weixiang (Drexel University)

Co-author(s) : Dr. RICHARDS, Gordon (Drexel University)

Presenter(s) : YU, Weixiang (Drexel University)

Session Classification : Methods and techniques

Contribution ID : **91** Type : **Poster**

AGN Variability Correlates

This poster will supplement the talk by Weixiang Yu. We will explore how AGN variability, as characterized by a Damped Harmonic Oscillator, correlates with other empirical AGN properties such as emission line parameters and multi-wavelength fluxes. Ultimately the goal is to learn how to best estimate physical properties like black hole mass and accretion rate, from the least amount of empirical data.

Primary author(s) : Prof. RICHARDS, Gordon (Drexel University); YU, Weixiang (Drexel University)

Presenter(s) : YU, Weixiang (Drexel University)

Session Classification : Poster

Contribution ID : **92** Type : **Poster**

Discovery of the lensed quasar eRASS1 J050129.5-073309 with SRG/eROSITA and Gaia

We report the discovery and NTT/EFOSC2 spectroscopic identification of a new bright doubly lensed quasar eRASS1 J050129.5-073309 at redshift $z = 2.47 \pm 0.03$. The source was selected from the first all-sky survey of the *Spectrum Roentgen Gamma (SRG)* eROSITA telescope and the *Gaia* EDR3 catalog. eRASS1 J050129.5-073309 is the optically brightest object in our sample and possesses remarkable properties. Legacy Survey DR10 imaging and image modeling reveal both the lensing galaxy and tentatively the lensed image of the quasar host galaxy. Archival optical light curves show evidence of a variability time delay where the fainter component lags the brighter by about 60 to 100 days. The fainter image has also decreased its brightness by about 1 magnitude since 2019. This dimming was still obvious at the time of the spectroscopic observations and is probably caused by microlensing. The discovery of this new lensed quasar and the time delay found in the optical light curve make eRASS1 J050129.5-073309 a suitable source for cosmological studies.

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Presenter(s) : TUBÍN, Dusán (Leibniz Institute for Astrophysics Potsdam)

Session Classification : Poster

Contribution ID : **93** Type : **Contributed talk**

The Unanticipated Phenomenology of the Blazar PKS 2131-021: A Unique Supermassive Black Hole Binary Candidate

Thursday, 29 June 2023 18:00 (15)

PKS 2131−021 is a blazar that shows peculiar variability in the radio light curve: within 45 years of recorded data, two epochs show strong sinusoidal variation with roughly the same period and phase, straddling a 20 year period when this variation was absent. We apply the Lomb-Scargle periodogram, weighted wavelet Z-transform and least-squares sine-wave analyses and address two pitfalls that are commonly ignored in periodicity studies of blazars: First, blazar light curves typically exhibit red noise variability, which makes it necessary to employ a large set of simulated light curves that reflect such a process. Second, when no a priori knowledge about the signal period exists, the look-elsewhere effect needs to be taken into account over the tested frequency range. Our statistical analyses demonstrate conclusively, at the 4.6σ significance level, that the periodicity in this object is not due to random fluctuations in flux density. A simple model can explain the sinusoidal variability as a result of modulated Doppler boosting due to the orbital motion of a Supermassive Black Hole Binary (SMBHB). The observed period of ˜2 years in the rest frame of the source suggests an orbital separation of ~0.001−0.01 pc. If truly a SMBHB and sufficiently massive, the gravitational waves produced by this system may be detectable with future pulsar timing arrays.

Primary author(s) : Dr. KIEHLMANN, Sebastian (Foundation for Research and Technology Hellas, Institute of Astrophysics); Prof. READHEAD, Anthony C. R. (Owens Valley Radio Observatory, California Institute of Technology); Ms. O'NEILL, Sandra (Owens Valley Radio Observatory, California Institute of Technology)

Presenter(s) : Dr. KIEHLMANN, Sebastian (Foundation for Research and Technology Hellas, Institute of Astrophysics)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **94** Type : **Poster**

A Highly Variable Radio-Loud Quasar in the Epoch of Reionization

Powerful radio jets are thought to play a key role in the formation and growth of supermassive black holes (SMBHs). They are also thought to have a significant effect on galaxy evolution. However, currently there is a dearth of radio sources at $z \geq 7$. I will present the discovery of the most distant radio-loud quasar known-to-date at $z = 7.0$, as well as the multi-wavelength follow-up studies of this unique object from X-ray to radio. I will discuss the nature of this highly variable source via multi-epoch multi-frequency radio observations, and the implications of its existence at such a high redshift. I will also present milliarcsecond resolution ($\sim$10s of pc scale) imaging of this source with the Very Long Baseline Array (VLBA).

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Presenter(s) : Dr. MOMJIAN, Emmanuel (NRAO)

Session Classification : Poster

Contribution ID : **95** Type : **Poster**

Compact Symmetric Objects: the evolution of a distinct class of jetted AGN

Compact Symmetric Objects (CSOs) are a class of compact jetted Active Galactic Nuclei (AGN) whose observed emission is not relativistically boosted towards us. While that makes them a unique class to understand jet processes, they are often misclassified and confused with other types of radio sources. Motivated by the need to clear the confusion in the literature, we compiled a catalog of 79 bona fide CSOs that meet strict classification criteria. Variability is one of the major criteria to distinguish CSOs from blazars. Using our newly defined complete samples, we conclusively demonstrate that most CSOs do not evolve into larger-scale radio sources, but are rather a distinct population of jetted AGN that is short-lived and has a sharp upper cutoff in the size distribution at ˜500 pc. Moreover, we demonstrate that there are two unrelated classes of CSOs: an edge-dimmed, low-luminosity class (CSO 1), and an edge-brightened, high-luminosity class (CSO 2), while CSO 2s can be further divided to CSO 2.0, CSO 2.1, CSO 2.2. CSO 2.0 have prominent hot-spots at the leading edges of narrow jets and/or narrow lobes; CSO 2.2 are without prominent hot-spots, and with broad jets and/or lobes; and CSO 2.1 exhibit mixed properties of CSO 2.0s and CSO 2.2s. The four classes occupy different, but overlapping, portions of the luminosity-size plane. The luminosity-size plane can be interpreted – analogous to the Hertzsprung-Russel-Diagram for stars – as depicting a population of CSOs in different evolutionary stages, where CSO 2s evolve from CSO 2.0s, which are young, through CSO 2.1s into CSO 2.2s, which are old. Thus, CSOs do not evolve into larger types of jetted AGN, but spend their whole life-cycle as CSOs. Different energy sources may originate the limited life-time evolution of CSOs, one of which may be single star capture – i.e. tidal disruption events. All of the above considerations make it clear that CSOs provide a unique window into the study of supermassive black holes, their accretion disks, and the birth of relativistic jets.

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Presenter(s) : KIEHLMANN, Sebastian (Institute of Astrophysics, Foundation for Research and Technology-Hellas)

Session Classification : Poster

Contribution ID : **96** Type : **Contributed talk**

Quasars with Periodic Variability: Capabilities and Limitations of Bayesian Searches for Supermassive Black Hole Binaries in Time-domain Surveys

Friday, 30 June 2023 15:30 (15)

Supermassive black hole binaries lurk, often unseen, in the centers of post-merger galaxies, and numerous electromagnetic surveys are seeking evidence of these dynamic duos' effects on their host galaxies. In this talk I'll discuss our recent paper, which analyzed the capabilities of promising methods to search for electromagnetic signatures of supermassive black hole binaries in current and future time domain surveys, including the Catalina Real-Time Transient Survey (CRTS) and the upcoming Legacy Survey of Space and Time (LSST). In this paper, we used Bayesian methods to disentangle periodic SMBHB signals from intrinsic damped random walk variability in AGN light curves. Through a careful analysis of parameter estimation and Bayesian model selection, we investigated the range of parameter space for which binary systems can be detected, and determined that the false-detection rate depends on the quality of the data and is minimal in LSST. I'll also discuss the promising implications this work has on the possibilities for multi-messenger astrophysics through partnerships with pulsar timing arrays, such as the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), which search for gravitational waves from these binaries.

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Presenter(s) : WITT, Caitlin (Northwestern University / Adler Planetarium)

Session Classification : Methods and techniques

Contribution ID : **98** Type : **Poster**

A narrow-line Seyfert 1 galaxy with disappearing broad-line region: J0413-0050

The multi-epoch observations over 15 years have led to the identification of a new class of active galactic nuclei (AGN), showing incredible spectral and flux changes: the changing-look (CL) AGN. The reason behind this peculiar behaviour could be changes in the accretion rate of the supermassive black hole, inducing variability in the continuum emission, or changes in the line-of-sight column density, possible due to a passing cloud or nuclear outflows, obstructing our view of the central engine. Here I present a peculiar object, 2MASX J04130709-0050165, identified as a narrow-line Seyfert 1 (NLS1) galaxy based on the Six-degree Field Galaxy Survey (6dFGS) spectrum. The 6dFGS spectrum taken in 2004 shows the classical features of an NLS1: narrow Hβ broad line emission and narrow forbidden lines. This source was recently observed again: with the New Technology Telescope in early 2021 and with the Nordic Optical Telescope at the end of 2021. These new spectra show the clear disappearance of the Hβ line while Hα line only changes in shape and the [OIII] line is unchanged. In my talk I will present the multi-wavelength data we retrieved and the comparison with the previous observations, showing how such a particular change in the spectral feature of this object is in agreement with the CL hypothesis. According to the preliminary results, the disappearance of the broad-line region, causing the dramatic spectral change, is consistent with a major change in the accretion rate. This could possibly indicate that the AGN is switching off, but more data will be necessary to confirm this scenario.

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Presenter(s) : VIETRI, Amelia (University of Padova)

Session Classification : Poster

Contribution ID : **99** Type : **Poster**

Does the lack of red giants around the Galactic center reveal past Galactic jet activity?

The reason for the missing red giants near the center of our Galaxy has long been debated. Over the past few decades, many publications and explanatory theories have been proposed for this phenomenon. A new analytical theory was suggested relatively recently, its essence is the idea of long-term ablation of the upper layers of the envelopes of red giants during repeated passages through a relativistic Galactic jet. We are currently engaged in detailed numerical modeling of this phenomenon. Using our advanced multidimensional hydrodynamical code, we calculate the ablation rate of these surface layers of a red giant star as it passes through a differently parameterized jet at different distances from the Galactic center. The initial state of the star, i.e. its density, pressure, and temperature profiles, is determined using the MESA evolution code. Subsequently, we also calculate the hydrodynamic behavior of stars after leaving such a jet since due to the exposure of the deeper subsurface layers of the star, its luminosity and spectral characteristics may change temporarily or even permanently. These changes, especially if we take into account a larger number of stars from the dense Nuclear Stellar Cluster undergoing a similar evolution, may contribute to visible changes in the observable characteristics within this region. We discuss applications to galactic nuclei in general, in particular AGN, since multiple and repeating stellar interactions with the jet also have an impact on its variability and density structure.

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Presenter(s) : Dr. KURFÜRST, Petr (Masaryk University)

Session Classification : Poster

Contribution ID : **101** Type : **Poster**

To the Torus and beyond: A multi-epoch study of obscuration in nearby AGN

Active galactic nuclei (AGN) are powered by accreting supermassive black holes, surrounded by a torus of obscuring material. The exact geometry of this material has been a subject of debate, as models have advanced from the initial homogeneous torus to a variety of possibilities, ranging from cloud distributions, to warped disks, to outflows. Recent studies have shown how the torus structure, formerly thought to be homogeneous, appears to be 'patchy': the detection of variability in the line-of-sight (los) hydrogen column density (NH_{los}), in fact, matches the description of an obscurer with a more complex structure made of clouds with different density. X-ray observations are the only way to probe the obscuring column density in the line of sight at any given time, and thus the optimal tool to place constraints on the exact distribution of this material.

In this work, we present a multiepoch X-ray analysis of 25 local obscured AGN, including a total of 131 X-ray observations, spanning more than 20 yrs of observing time. Surprisingly, we observe large differences between l.o.s. column densities and average torus column densities for most sources. In some of the sources, the addition of an "inner" ring of denser material (NH>10^{25}cm^{-2}) is required to properly model the reflection component of the spectra. This suggests that the material responsible for obscuration and reflection is not the same, pointing toward added complexities in the torus structure. We also conclude that variable sources tend to have higher obscuration in average (i.e. denser tori), and broader cloud distributions.

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Presenter(s) : PIZZETTI, Andrealuna (Clemson University)

Session Classification : Poster

Contribution ID : **102** Type : **Poster**

Multiwavelength monitoring of the nucleus in PBC J2333.9-2343: the giant radio galaxy with a blazar like core

PBC J2333.9-2343 is a giant radio galaxy at z = 0.047 with a bright central core associated to a blazar nucleus. If the nuclear blazar jet is a new phase of the jet activity, then the small orientation angle suggest a dramatic change of the jet direction. We present observations obtained between September 2018 and January 2019 (cadence larger than three days) with Effeslberg, SMARTS-1.3m, ZTF, ATLAS, Swift, and Fermi-LAT, and between April-July 2019 (daily cadence) with SMARTS-1.3m and ATLAS. Large (>2 x) flux increases are observed on timescales shorter than a month, which are interpreted as flaring events. The cross correlation between the SMARTS-1.3m monitoring in the NIR and optical shows that these data do not show significant time lag within the measured errors. A comparison of the optical variability properties between non-blazars and blazars AGN shows that it has properties more comparable to the latter. The SED of the nucleus shows two peaks, that were fitted with a one zone leptonic model. Our data and modelling shows that the high energy peak is dominated by External Compton from the dusty torus with mild contribution from Inverse Compton from the jet. The derived jet angle of 3 degrees is also typical of a blazar. Therefore, we confirm the presence of a blazar-like core in the center of this giant radio galaxy, likely a Flat Spectrum Radio Quasar with peculiar properties.

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Presenter(s) : HERNANDEZ-GARCIA, Lorena

Session Classification : Poster

Contribution ID : **104** Type : **Contributed talk**

Latent SDEs for Modelling Quasar Variability and Inferring Black Hole Properties

Friday, 30 June 2023 16:00 (15)

Active galactic nuclei (AGN) are thought to be powered by the accretion of matter around supermassive black holes at the centers of galaxies. The time-dependent variability of an AGN's brightness can provide valuable insights into the physical characteristics of its underlying black hole. The variability can be well modeled by a damped random walk process described by a stochastic differential equation (SDE). Upcoming wide-field telescopes such as the Rubin Observatory Legacy Survey of Space and Time (LSST) are expected to observe 100 million AGN in multiple bandpass filters, so new methods need to be developed to analyze the large volume of light curve data. Latent SDEs are variational auto encoders (VAEs) with a neural SDE as the decoder. Latent SDEs are well suited for modeling the AGN time series, as they explicitly model the underlying dynamics. We modify latent SDEs to jointly reconstruct the unobserved portions of multivariate AGN light curves as well as infer their physical properties, such as the black hole mass. We train our model on a realistic physics-based simulation of ten-year LSST light curves and find our method outperforms a multi-output Gaussian process regression in light curve reconstruction. Our method has the potential to provide a deeper understanding of the physical properties of black holes and AGN variability and may be applicable to a wide range of other astronomical times series.

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Presenter(s) : FAGIN, Joshua (CUNY)

Session Classification : Methods and techniques

Contribution ID : **105** Type : **Poster**

A disk instability model for the quasi-periodic eruptions

Five QPE (quasi-periodic eruption) sources have been detected in the past few years. But so far, the mechanism of QPE is still unclear. In this talk, I will introduce you to a disk instability model based on \citet{2021ApJ...910...97P} (PLC21) to explain GSN 069 and other QPEs. We improve the work of PLC21 to include a non-zero viscous torque condition at the inner boundary of the disk and adopt a general form of viscous stress torque in the Kerr metric. It was found that our model can qualitatively reproduce both the light curve and the phase-resolved X-ray spectra of these sources.

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Presenter(s) : PAN, Xin (Shanghai Astronomical Observatory)

Session Classification : Poster

Contribution ID : **106** Type : **Contributed talk**

STAR-X: a next-generation X-ray and UV explorer to study the restless nature of AGN

Wednesday, 28 June 2023 13:15 (15)

The Survey and Time-domain Astrophysical Research eXplorer (STAR-X; http://star-x.xraydeep.org) is a Medium Explorer class mission recently selected for a competitive NASA Phase A study. It comprises a wide-field, high-throughput, high-angular-resolution X-ray Telescope (XRT) and a complementary UV Telescope (UVT) on an agile spacecraft bus. STAR-X will conduct high-cadence, deep-and-wide surveys, and respond rapidly to transient events discovered by other observatories such as LIGO, Rubin/LSST, Roman/WFIRST, and SKA.

The science theme for the mission is "to study the fast, furious and forming Universe." In this talk I will first present an overview of the mission concept and observing capabilities, and then focus on the key "furious" science pillar, which will explore feeding and growth of massive black holes through sensitive, time-domain studies.

STAR-X will uniquely probe the physics of rapid accretion that allowed the formation of the first supermassive black holes, and will catch transient, extreme black hole feeding events, such as Tidal Disruption Events (TDEs). Critically, STAR-X will discover TDEs in the X-ray band, providing direct evidence for newborn accretion disks. Also, by monitoring their X-ray and associated UV emission, STAR-X will constrain the timescales of disk formation and their evolution. Finally, STAR-X will perform detailed reverberation mapping of AGN distributed over a broad range of Eddington ratios, revealing how the accretion flow geometry depends on the accretion rate.

Primary author(s) : Dr. GILLI, Roberto (INAF - OAS Bologna); ON BEHALF OF THE STAR-X TEAM

Presenter(s) : Dr. GILLI, Roberto (INAF - OAS Bologna)

Session Classification : Current and Future Surveys

Contribution ID : **107** Type : **Invited talk**

Review: On the complementarity of time domain techniques for detecting close binary supermassive black hole candidates: interferometric/(spectro)astrometric observables and periodicity detection

Friday, 30 June 2023 15:00 (30)

The supermassive black hole (SMBH) binary systems are important for testing the models of SMBH formation, comparing the physics of SMBH merging to gravitational wave (GW) detection, and determining the stochastic GW background at low frequencies, just to name a few.

We present an overview of current efforts on combining information from complementary techniques to detect close binary supermassive black holes (CB-SMBH, components bound in a Keplerian pair at mutual distances of less than 0.1 pc). This topic has typically been driven by theoretical work, but in recent years it has also generated interest in observational astronomy.

A variety of parameters influence CB-SMBH observability, the bulk of which are dictated by the system's evolutionary stage. Throughout electromagnetic domains, samples of dual SMBH systems separated by kiloparsecs to hundreds of parsecs have been detected. Nevertheless, the evidence is not as obvious at subparsec scales due to a lack of instrumental resolution to separate the binary components features in highly dimensional observability space. Moreover, a binary SMBH ensemble should provide a stochastic gravitational wave (GW) background with a distinct strain form. The Pulsar Timing Array (PTA) might resolve massive or nearby SMBH binaries from the GW background, but only during the early inspiral stage of a binary merger, in addition to supplying GW information for the ensemble of binary systems.

Thus, to expand the explored parameter space of CB-SMBHs and follow them up with coming nano-Hz GW interferometers (or PTA), we should employ all available time domain observations to identify the physical parameters of CB-SMBHs and noteworthy candidates. Using time domain data sets collected over several techniques, rather than just one, should enhance the amount and quality of information on the observed object. Even if one of the data sets is far more inaccurate than the other, this is supposed to be true.

Given the increasing amount of data from already existing and future large sky surveys, as well as the growing population of high resolution imaging tools capable of scanning individual objects with ever-sharper vision, the combined information from these advanced techniques has the potential to uncover a substantial portion of CB-SMBH candidates.

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Presenter(s) : Prof. KOVAČEVIĆ, Andjelka (Department of astronomy, Faculty of mathematics, University of Belgrade)

Session Classification : Methods and techniques

Contribution ID : **108** Type : **Contributed talk**

Modified models of radiation pressure instability as a potential cause of Changing-Look AGN phenomenon

Tuesday, 27 June 2023 13:00 (15)

Apart from regular, low-level stochastic variability, some AGNs occasionally show exceptionally large changes in luminosity, spectral shape, and/or X-ray absorption. The most notable are the changes of the spectral type when the source classified as a Seyfert 1 becomes a Seyfert 2 galaxy or vice versa. Thus a name was coined as 'Changing-Look AGN' (CL AGN). The origin of this phenomenon is still unknown, but for most of the sources, there are strong arguments in favor of intrinsic changes.

Understanding the nature of such rapid changes is a challenge to the models of black hole accretion flows since the timescales of the changes are much shorter than the standard disk viscous timescale, related to changes in angular momentum distribution. We aim to model the CL AGN phenomenon using the time-dependent evolution of a black hole accretion disk unstable due to the dominant radiation pressure. We use a 1-dimensional, vertically integrated scheme, and focus on the variability timescales and amplitudes, which can be regulated by the action of large-scale toroidal magnetic fields and the presence of an inner optically thin flow, like Advection-Dominated Accretion Flow (ADAF). We thus modify the inner boundary condition of the cold disk flow, and we mimic the formation of the MRI-inactive zones, that suppress instabilities, by parameterizing their relative importance according to a local accretion rate. We succeed to model the timescales of tens of years that correspond to timescales of observed repetitive outbursts in CL AGN, such as NGC 1566 or NGC 4151. However, other interpretations of quasar variability are still open and most probably more than one mechanism is responsible for changes observed in CL AGN.

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Presenter(s) : SNIEGOWSKA, Marzena (Tel Aviv University)

Session Classification : Accretion and variability theory

Contribution ID : **109** Type : **Contributed talk**

Time variability of ultra-fast outflows in BAL quasars using SALT: C IV equivalent width analysis

Friday, 30 June 2023 10:30 (15)

We present the results of a South African Large Telescope (SALT) spectroscopic monitoring to study the time variability of C IV BALs in a sample of 64 quasars showing ultra-fast outflow (UFO) with $v_{outflow,max}$ > 15000 kms^{-1} in their spectra. We also created a sample of non-BAL quasars from SDSS DR12 matched in redshift and luminosity. Our UFOs show more blueshift of CIV BEL than that of non-BALs in the control sample. The fraction of "highly variable" BALs (with fractional change in equivalent width, $\frac{\Delta W}{W}$ > 2) in our sample is considerably higher than that reported for the general BAL population. We find that the strength of variability increases with time, and for each source, SALT observations enabled us to look at the variability at different time scales (from as short as < 0.5 years to longer time scales of > 7.5 years) in detail. We also show that the fraction of highly variable BALs increases with time, and for these BALs, the BAL strengthening time scale is found to be considerably shorter than the weakening time scales. We found no correlation between BAL variability and quasar properties such as black hole mass and Eddington ratio but found a moderate correlation with bolometric luminosity for time scales < 2 years. Based on the properties of C IV absorption, we find weak, high-velocity, shallow, and low-width BALs tend to show more variability. We also classified the BALs according to their absorption profile shape and found detached profiles at high velocities showing large variations irrespective of the strength of absorption. We conclude both the low-equivalent width and high-velocity nature of BALs are equally important for excess BAL variability. Interestingly our results suggest that the presence of a distinct BAL trough at lower velocities increases the chances of observing a highly variable UFO BAL if present. Finally, using photometric light curves, we show that the continuum flux variations may be responsible for the observed BAL variability in the majority of the sources where the EW of the BAL decreases as the continuum increases.

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Session Classification : Outflows

Contribution ID : **112** Type : **Contributed talk**

ZTF constraints on variability from intermediate-mass black hole candidates

Tuesday, 27 June 2023 18:00 (15)

Intermediate-mass black holes (IMBHs) are key pieces in the puzzle of extragalactic and galactic astronomy, due to their potential to answer questions related the formation and evolution of supermassive black holes and co-evolution with their host galaxies, among others. Because of the difficulties present when detecting and confirming sources as IMBHs, they have proven to be an elusive population. Accreting BHs are known to show random variability in different spectral bands (optical, UV, etc.). We aim to demonstrate the viability of optical variability as a technique to select IMBHs candidates and characterize a sample of IMBHs obtained from the literature. Using ZTF forced photometry on the difference image, and various variability features, we obtain a high-confidence IMBHs candidates subgroup. We aim to study the multi-wavelength properties of the selected subsample and discuss it's implications in the AGN paradigm.

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Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **113** Type : **Poster**

Interpretation of IR variability of AGNs in the hollow, bi-conical, dust-outflow model.

We show that, contrary to simple predictions, most AGNs show at best only a small increase of lags inthe J, H, K, and L bands with increasing wavelength. We suggest that a possible cause of this near simultaneity of the variability from the near-IR to the mid-IR is that the hot dust is in a hollow bi-conical outflow of which we only see the near side. In the proposed model sublimation or recreation of dust in some cloud along our line of sight in the hollow cone could be a factor in explaining the changing look phenomenon of an AGN. The relative wavelength independence of IR lags simplifies the use of IR lags for estimating cosmological parameters.

Primary author(s) : Dr. OKNYANSKY, Victor (University of Haifa)

Co-author(s) : Dr. GASKELL, C. Martin (University of California Santa Cruz)

Presenter(s) : Dr. OKNYANSKY, Victor (University of Haifa)

Session Classification : Poster

Contribution ID : **114** Type : **Poster**

Open-source X-ray reverberation modelling

X-ray reverberation models provide an unprecedented view of accretion processes in active galactic nuclei (AGN), allowing us to probe deep into the innermost regions close to the singularity. To date, spectral and variability models have been successful in studying certain coronal structures and disc geometries, mandating increasingly specialized codes to simulate complex reverberating systems. These codes are time consuming to develop, and often require compromising assumptions and approximations in order to be performant. We present Gradus.jl, a new extensible, reproducible and fast open-source Julia library for general relativistic ray-tracing and reverberation modelling. Our code expedites the process of studying new coronal models and disc geometries for X-ray reverberation. We overcome current modelling limitations through automatic differentiation and state-of-the-art optimizers, with little impact on performance. We invite anyone to use our code to accelerate developing novel reverberation models for AGN and beyond.

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Co-author(s) : Dr. YOUNG, Andrew (University of Bristol)

Presenter(s) : Mr. BAKER, Fergus (University of Bristol)

Session Classification : Poster

Contribution ID : **115** Type : **Poster**

Twisted (lensed) quasar light curves for continuum reverberation mapping

High-cadence and multi-band photometric monitoring facilities are important for measuring quasar accretion disk size with continuum reverberation mapping. The method measures signal propagation time from center to outer parts of the central engine, assuming time shifts in continuum light curves at different wavelengths. However, high-quality light curves show that light curves at different wavelengths are not only shifted, but also distorted due to a transfer function increasing with wavelength. We illustrate the impact on the delay measurements using JAVELIN, CREAM, and PyCS methods, with simulated light curves in the LSST ugrizy bands. We also propose a brute-force method for measuring disk size with microlensing multi-band light curves in lensed quasars.

Primary author(s) : Dr. CHAN, James (AMNH)

Presenter(s) : Dr. CHAN, James (AMNH)

Session Classification : Poster

Contribution ID : **116** Type : **Contributed talk**

Unveiling the periodic variability patterns of the multiwavelength light emission from the blazar PG 1553+113

Friday, 30 June 2023 12:30 (15)

The characteristic variability of blazars is being since long time explained by relating it to a wide range of possible physical processes, occurring in the accretion disk and/or the jet. The various scenarios include emission spots in the accretion disk revolving around the supermassive black hole, magnetohydrodynamic instabilities in the disk or the jet, shocks traveling along turbulent jets, and relativistic effects due to the jet orientation. In the X-ray band, the background emission generated by the accretion disk seems to outshine any possible additional source of variability, such as the periodicity induced by the presence of a binary black hole in the central engine. The purpose of our work is the search of periodicity in the X-ray, UV and optical light curves of the blazar PG 1553+113 with Swift-XRT data spanning ten years from 2012 to 2022. This source is already known to exhibit periodic variability in the optical and the gamma-rays with a period of 2.2 yr only, we have performed a robust statistical analysis of the light curve. Our results confirm that the PG 1553+113 X-ray emission displays a periodicity shorter by a factor of ˜40% than the gamma-ray one. We also investigated the cross-correlations between the light curves of this source in several bands, in search of possible time delays that could help to discriminate the spatial distribution of the various emitting region.

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Presenter(s) : ANIELLO, Tommaso (INAF OAR)

Session Classification : Radio loud AGN

Contribution ID : **120** Type : **Poster**

Varstrometry for Dual AGN using Radio Interferometry (VaDAR)

Binary and dual active galactic nuclei (AGN) are an important observational tool for studying the dynamical evolution of galaxies and supermassive black holes (SMBH). However, they are notoriously difficult to unambiguously detect due to current observational limits and biases, and are often identified serendipitously. An entirely new method for identifying possible AGN pairs makes use of the exquisite positional accuracy of *Gaia* to detect astrometrically-variable quasars, in tandem with the high radio spatial resolution of the Very Large Array (VLA) and the Very Long Baseline Array (VLBA). Colloquially called *varstrometry*, this process can be used to measure emission flux, place limits on source angular size and separation, and make an in-depth investigation of source morphology. We present new radio observations of 18 quasars (at redshifts between 0.7 and 2.9), selected from the SDSS DRQ16 and matched with the *Gaia* EDR3. All 18 targets are identified by their excess astrometric noise in *Gaia* with high significance (>5σ), meaning that each source exhibits positional variability ("jitter"). We targeted these 18 quasars with the VLA 2-4 GHz (S band) and 8-12 GHz (X band), providing resolutions of 0.65 and 0.2 arcseconds, respectively, in order to constrain the origin of this variability. We combine these data with the several radio surveys (VLASS, FIRST, etc.) in addition to multiwavelength archival and survey data from DECaLS and WISE. We also present preliminary results from new radio observations of a sub-sample of 7 quasars, which were observed with the VLBA at S- and X-band, providing milliarcsecond scale constraints on the origin of the jitter. Taken together, we will constrain the possible causes of the astrometric variability, including jet activity/dynamics, single AGN variability, obscuration variability, and dual/binary AGN activity. Ultimately, we use this new strategy to help identify and understand this sample of astrometrically-variable quasars, using *Gaia*'s astrometric observations in conjunction with radio and multiwavelength data.

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Presenter(s) : SCHWARTZMAN, Emma (US Naval Research Lab/George Mason University)

Session Classification : Poster

Contribution ID : **121** Type : **Contributed talk**

A repeating partial tidal disruption event discovered by eROSITA

Thursday, 29 June 2023 12:45 (15)

During its first two years of the All-Sky Survey, SRG/eROSITA uncovered a large sample of X-ray transients associated with the nuclei of quiescent galaxies. In this talk, I will highlight one exceptional repeating nuclear transient eRASSt J045650-203751 discovered by SRG/eROSITA. Extensive monitoring with XMM-Newton, Swift, NICER, and ATCA revealed four repeating X-ray flares and repeating transient radio emission. This makes J0456-20 one of the most promising repeating partial Tidal Disruption Event (pTDE) candidates. A detailed analysis of the available data shows that the characteristic X-ray variability for each flare can be best explained by the accretion state transitioning between the thermal and the steep power-law states, accompanied by the formation and destruction of the coronae. This indicates that similar accretion processes are at work across a broad range of BH masses and accretion rates and that the corona can be formed and destructed within a few weeks to months. I will also present evidence of a potential evolution of the recurrence time of the flares, hinting at a change in the orbital period of the stellar remnant. This highlights the role of repeating pTDEs as effective probes of the stellar dynamics around supermassive BHs beyond our Galaxy.

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Presenter(s) : LIU, Zhu

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **122** Type : **Poster**

Multi-Wavelength Reverberation Mapping Survey Synergies Between Future Facilities

In the present era of astronomical surveys, multi-wavelength studies are gaining ground. Active galactic nuclei (AGN), powered by the accretion of matter onto their central supermassive black hole, emit over a broad range of wavelengths from the X-ray to radio. Therefore, exploring AGN at multiple wavelengths is critical to understand the energetics of these powerful engines. Because AGN appear point-like (angular sizes of μarcseconds), the time-domain technique of reverberation mapping (RM) is applied to map their inner regions. RM utilizes the variability timescales between different continuum wavelengths ('accretion-disk RM') or between the continuum and nearby gas in the broad-line region ('broad-line region RM') to infer the size scales of AGN. AGN sizes combined with broad-line gas velocities yield masses of the central black holes in these objects. Despite decades of efforts, the key question of *'How do supermassive black holes grow over cosmic time?'* remains unsolved. Investigating a significantly large sample of AGN spanning a breadth of redshifts and luminosities is important for constraining the history of black hole growth over cosmic time. We aim to design a large-scale AGN RM campaign with the *Cosmological Advanced Survey Telescope for Optical and ultraviolet Research (CASTOR)* to obtain black hole masses in a large AGN sample over a wide luminosity-redshift space with imaging and slitless (grism) spectroscopy. *CASTOR* is a Canadian flagship ultraviolet (UV) mission proposed to the Canadian Space Agency. UV is essential because it probes the AGN ionizing continuum; additionally, AGN are more variable and vary on shorter timescales in the UV than in the optical and infrared. With *CASTOR*, we will probe black hole masses in a unique phase space of redshifts and luminosities as compared to all previous RM studies. Furthermore, synergies between *CASTOR* and future ground-based facilities such as the Vera C. Rubin Observatory and the Maunakea Spectroscopic Explorer will allow expanding the science outcomes of *CASTOR* AGN surveys to longer wavelengths in the optical and infrared. In my talk, I will cover how we are planning large-scale AGN RM surveys with a survey simulation tool and show synergies between *CASTOR* and next-generation ground-based observatories.

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Session Classification : Poster

Contribution ID : **123** Type : **Contributed talk**

The multifaceted variability of the Seyfert AGN MCG+08-11-11

Monday, 26 June 2023 10:30 (15)

Over the last decade reverberation mapping (RM) campaigns of active galactic nuclei (AGN) have enabled us to probe their inner regions in unprecedented detail. Whilst observations have broadly confirmed that the short-term variability of the accretion disc is driven by variations in the X-ray corona a number of puzzles have also emerged, including: the contribution of the broad line region (BLR) to measured lags; the implied large disc sizes; the role of disc winds as obscurers or additional reprocessors; and unexpectedly long X-ray to UV lags.

To address these issues I present results from a superb new multi-wavelength data set on the bright Seyfert galaxy MCG+08−11−11. This major, high-cadence monitoring campaign, conducted with *Swift* and ground-based observatories, captured the source in an unusually highly-variable phase compared with previous observations: rapid, large-amplitude flux changes are observed at all wavelengths. We find that the X-ray and UV-optical lightcurves are much more highly-correlated than typically found in similar RM studies. The wavelength-dependent lags form a spectrum that approximates disc reprocessing predictions. The behaviour of the source was markedly different during an optical RM campaign conducted just a year prior in which only slow and moderate flux changes were seen; the resultant lag spectrum was very much steeper during this period, likely because of a stronger contribution from the BLR. Our new results further emphasise that a simple, static reprocessing geometry cannot explain the observed variability: even in the same source, different reverberating components (or processes) dominate at different times. This rich data set provides a golden opportunity to grapple with the dynamic and complex nature of AGN variability, and I discuss the broader implications.

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Presenter(s) : Dr. KYNOCH, Daniel (University of Southampton)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **124** Type : **Contributed talk**

Resolving the BLR with VLTI/GRAVITY

Tuesday, 27 June 2023 10:00 (15)

With VLTI/GRAVITY and near-infrared (NIR) interferometry, we can directly spatially resolve the broad-line region (BLR) to probe its physics and derive supermassive black hole (SMBH) masses via dynamical modelling. This method provides an independent test of the assumptions of reverberation mapping (RM), which has been the main method used so far to study the small scales associated with the BLR. In this talk, I will present our study of 7 type 1 AGNs observed with VLTI/GRAVITY. All of our studied BLRs can be well described by a thick, rotating disk of clouds. For each individual AGN, though, we can trace substructure and non-circular motions. For Mrk 509 and PDS 456 in particular, we find evidence for significant outflows. Interestingly, we find significant spatial offsets between average photocenters of the hot dust continuum and the BLR (ranging from $\sim$17μas to 140μas), which seem to follow a tight relationship with the AGN luminosity. I will discuss our interpretation of this relation, together with the implications of our results with RM, the physics of the BLR, and scaling relations such as the radius-luminosity (R-L) and black hole mass – stellar velocity dispersion ($M_{\rm BH}$ - σ_*) relations.

Primary author(s) : SANTOS, Daryl Joe (MPE); Dr. SHIMIZU, Taro (MPE); Dr. SHANGGUAN, Jinyi (MPE); Dr. CAO, Yixian (MPE); Dr. DAVIES, Richard (MPE); Dr. LUTZ, Dieter (MPE); Dr. STURM, Eckhard (MPE)

Presenter(s) : SANTOS, Daryl Joe (MPE)

Session Classification : Emission Line variability

Contribution ID : **125** Type : **Invited talk**

Review: Extreme variability of AGNs: Tidal Disruption Events

Thursday, 29 June 2023 11:30 (30)

Tidal disruptions of stars by supermassive black holes were proposed in the 1970s as a possible way of fuelling active galactic nuclei. Following further studies showing that this mechanism can not supply quasar-level fuelling rates, it was realized that bright flares produced by disruptions could be used as probes for exploring otherwise quiescent galactic centres. In the last decade the study of Tidal Disruptions Events (TDEs) gained momentum from advanced numerical simulations on the theoretical side and from detections of dozens of TDEs by wide-field sky surveys on the observational side.

I will review the theoretical picture of TDEs, main mechanisms and parameters affecting the outcome of a stellar encounter with a black hole, and their observed characteristics. I will address main open questions stemming from simulations and observations, and the prospects of Rubin Observatory LSST in discovering TDEs, and significantly enlarging their sample.

Primary author(s) : GOMBOC, Andreja (University of Nova Gorica)

Presenter(s) : GOMBOC, Andreja (University of Nova Gorica)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **126** Type : **Contributed talk**

X-ray variability of SDSS quasars

Monday, 26 June 2023 18:15 (15)

I present the analysis of a sample of several hundred SDSS quasars with multiple serendipitous XMM-Newton observations. The X-ray to UV luminosity relation allows to predict the average X-ray flux, and to select only the X-ray observations that are deep enough to remove any bias towards higer-than-average flux states. The optical/UV SDSS spectrum allows to investigate the relation between X-ray variability and the total luminosity, the black hole mass, and the Eddington ratio. Considering that the optical/UV and X-ray observations are not correlated, I conclude that most of the "intrinsic" dispersion of the X-ray to UV relation is due to X-ray variability.

Primary author(s) : Prof. RISALITI, Guido (Università di Firenze); Ms. SIGNORINI, Matilde (Università di Firenze); Dr. LUSSO, Elisabeta (Università di Firenze); Dr. NARDINI, Emanuele (INAF-Arcetri Observatory)

Presenter(s) : Prof. RISALITI, Guido (Università di Firenze)

Session Classification : X-ray continuum variability

Contribution ID : **127** Type : **Contributed talk**

Ensemble Power Spectral Density of AGN in optical bands

Tuesday, 27 June 2023 15:30 (15)

Variability of AGN in all wavelengths has been known for decades, with timescales ranging from days to years. However, the physical mechanisms driving such variability are still unclear. X-ray Power Spectral Densities (PSDs) are usually well represented by power laws with slopes α ˜ -1 at low frequencies, and α ˜ -2 at high frequencies. Similar power-law trends have also been observed in UV/optical bands, but with a much lower break frequency. Optical variability is typically studied through Structure Function (SF) and modeled with a Damped Random Walk (DRW), implying a PSD with slopes at low and high frequencies, α=0, α=-2, respectively. Despite the good agreement of the DRW model on timescales from several months to a few years, many works show significant deviations on both longer and shorter timescales, along with strong uncertainties in determining the position of the break.

I will present a completely model independent study of AGN optical variability through ensemble PSD analysis on archival data. The wealth of information about bolometric luminosities and black hole masses enable the study of correlations between the variability amplitude and the AGN physical properties. PSD also has the advantage that its estimates at different frequencies are uncorrelated and with well known statistical properties. Moreover, as X-ray variability is usually studied through PSDs, using the same tool for optical bands provides better constraints on different variability models. Results from this analysis will be further boosted by the upcoming Legacy Survey of Space and Time (LSST), which will increase both the size of the sample and the temporal baseline, compared to previous surveys.

Primary author(s) : PETRECCA, Vincenzo (Università di Napoli Federico II)

Co-author(s) : PAOLILLO, MAURIZIO (Università di Napoli Federico II); PAPADAKIS, Iossif

Presenter(s) : PETRECCA, Vincenzo (Università di Napoli Federico II)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **128** Type : **Poster**

Probing the BLR geometry and kinematics for quadruply lensed quasar Q2237+0305 with time series

The quadruply lensed quasar Q2237+0305 at z = 1.695, known as the Einstein cross, has been known for years to be a privileged laboratory for microlensing studies due to very short time lags. The spectra of the image A reveals a strong magnification effect that distorts the broad CIV emission line, while the image D shows no microlensing induced variability. The BLR microlensing is characterized with three observables (indices) calculated from the broad line: μ^{BLR}, WCI, RBI (Hutsemékers et al. 2019).

We model microlensing by convolving the magnification map with three representative BLR geometries: Keplerian disk (KD), polar wind (PW) and equatorial wind (EW). Variability is modeled by linear motion of a point source over the convolved images. We directly compare for which model parameters the extracted time series match with the observed indices. The preferred geometry is KD and the most likely BLR mean radius is 63 ± 20 light days (for CIV line). We discuss the possibilities of extending our method to other lensed quasars as well as large datasets.

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Presenter(s) : Dr. SAVIĆ, Djordje (Institut d'Astrophysique et de Géophysique, Université de Liège, Allée du 6 Août 19c, 4000 Liège, Belgium)

Session Classification : Poster

Contribution ID : **129** Type : **Contributed talk**

Opportunities and challenges for spectral-timing models of AGN

Monday, 26 June 2023 16:15 (15)

X-ray reverberation mapping studies of AGN can, in principle, be used to measure the black hole mass and spin, the accretion disc and corona geometries, and the ionisation state of the disc. We report on our efforts to fit the spectra and time lags of a number of AGN, but focus primarily on two sources, 1H 0707-495 and IRAS 13224-3809. We can explain the low- and high-frequency lags, find that an extended corona is required, estimate the black hole masses, and find there are different correlations between parameters in each object as their coronae change. However, this model is slow to evaluate, the parameter space had to be limited (e.g., fixed spin; simplified geometry), it was difficult to characterise the error bars and degeneracies in the model, and the data were fairly noisy. We will discuss how new approaches to modelling and improved data will lead to a better understanding of the inner workings of AGN.

Primary author(s) : YOUNG, Andrew (University of Bristol)

Presenter(s) : YOUNG, Andrew (University of Bristol)

Session Classification : X-ray continuum variability

Contribution ID : **130** Type : **Contributed talk**

MgII radius-luminosity relation: applications to the BLR structure and cosmology

Tuesday, 27 June 2023 10:30 (15)

By long-term spectroscopic and photometric monitoring of three luminous intermediate-redshift quasars (CTS C30.10, HE 0413-4031, HE0435-4312) by the SALT telescope, we have been able to progressively constrain the parameters of the MgII radius-luminosity (R-L) relation (Czerny+2019, Zajacek+2020, Zajacek+2021). The MgII line variability is comparable to the continuum variability and the MgII light curve is significantly correlated with respect to continuum light curve. Thanks to that, we were able to infer the rest-frame time delays of the MgII emission, which are 276, 303, and 296 days for CTS C30.10, HE 0413, and HE0435, respectively. In combination with SDSS and OzDES reverberation mapping programs, which monitored lower-luminosity sources, the MgII R-L relation is constrained well using 94 sources up to now. The luminous quasars are crucial for enhancing the R-L correlation. The MgII R-L relation has a large vertical scatter of ˜0.39 dex and a slope of ˜0.3, which is in tension with the simple photoionization theory. We compare the MgII R-L relation with optical Hbeta, optical and UV FeII relations. The flatter slope of MgII R-L relation with respect to other R-L relations could be caused by the bias towards higher-Eddington, intermediate-redshift sources whose time delays are shortened for a given luminosity. In addition, we show that MgII R-L relation parameters are independent of the adopted cosmological model, and thus the monitored quasars can be standardized and applied for constraining cosmological parameters of different models (flat and non-flat cosmological models with general dynamical dark energy). Inferred cosmological constraints are weak but consistent with better established cosmological probes.

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Presenter(s) : ZAJAČEK, Michal (Masaryk University)

Session Classification : Emission Line variability

Contribution ID : **131** Type : **Contributed talk**

Searching for X-ray eclipses in NGC 6814 using dense optical/UV to X-ray monitoring with Swift

Monday, 26 June 2023 15:15 (15)

NGC 6814 is a nearby ($z = 0.005$) Seyfert 1.5 galaxy that we recently showed had undergone a rapid X-ray occultation event during an *XMM-Newton* observation from 2016. The X-ray eclipse of high column ($N_{\rm H} \approx 10^{23}$ cm^{-2}), mildly ionised ($\log \xi \approx 1$ erg cm s^{-1}) matter lasted ˜45ks, with ingress and egress each lasting ˜14ks, revealing a partially covered X-ray region we estimated to be ˜25 gravitational radii across. From August to November 2022 we observed NGC 6814 3-4 times per day with *Swift* to search for new X-ray eclipses to better understand the environment in this AGN. We present here a new analysis of the 2016 *XMM-Newton* data using X-ray colour-colour diagrams that reveal an inhomogeneous, clumpy obscurer, which is likely embedded within an extended, large scale structure based on simultaneous and long-term *Swift* coverage. Our 2022 *Swift* campaign reveals no new X-ray eclipses, but offers a rich data set with which we conduct the first thermal reverberation analysis of this AGN. We find highly correlated optical/UV to X-ray variability that exhibits a significantly flatter time-lag spectrum than the predicted 4/3 power law relation of a standard X-ray illuminated accretion disc. Furthermore, we find that during the 2016 X-ray eclipse X-rays de-correlate from optical/UV variation before resuming highly correlated broad band variability ˜30 days later.

Primary author(s) : Dr. GONZALEZ, Adam (Saint Mary's University); Mr. POTTIE, Ben (Saint Mary's University); Prof. GALLO, Luigi (Saint Mary's University); Prof. MILLER, Jon (University of Michigan); Dr. KAMMOUN, Elias (Institut de Recherche en Astrophysique et Planétologie (IRAP))

Presenter(s) : Dr. GONZALEZ, Adam (Saint Mary's University)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **132** Type : **Poster**

Studying Changing-Look AGNs using variability and light curves

The discovery of ˜100 changing-look AGNs, i.e., changing their optical spectral types between type-I and II, challenges the AGNs unified model that uses the orientation to explain the difference between these two AGN subclasses. Recent works demonstrate that the large difference in the optical variability between type-I and type-II AGNs can be used to distinguish these two spectral types. We took MDM and Gemini spectra of a dozen of AGNs currently showing light curves inconsistent with their known types in the literatures, classified by light curve classifier $qsofit$ using ZTF light curves from our independent analysis. We successfully obtain a sample of new H beta changing-look AGNs, many of which still have weak broad Hα line in their faint states, indicating that they are weak type-I AGNs. Our results favour the large change in the accretion rates to be responsible for the appearance/disappearance of the Hβ profiles of these objects. We will briefly discuss the typical timescale and Eddington ratios of changing-look AGNs using our sample.

Primary author(s) : WANG, Shu (Seoul National University); Prof. WOO, Jong-Hak (Seoul National University); GUO, Hengxiao

Presenter(s) : WANG, Shu (Seoul National University)

Session Classification : Poster

Contribution ID : **133** Type : **Contributed talk**

Revisiting the dust torus size - luminosity relationship in AGN based on the mid-infrared reverberation mapping data

Monday, 26 June 2023 15:00 (15)

We measured the dust torus size of 86 quasars with bolometric AGN luminosity in the range 10ˆ43.4 to 10ˆ46.4 erg/s by determining the lag between the optical continuum emission obtained from ground-based optical surveys, i.e., CRTS, ASAS-SN, PTF and ZTF, and the mid-infrared continuum observed with the W1 and W2 bands from the Wide-field Infrared Survey Explorer (WISE) survey. By combining the new measurements with our re-analyzed measurements of the sample in the literature, we constrain the torus size - AGN luminosity relation over a large dynamic range of luminosities (i.e., 10ˆ43.4 to 10ˆ47.6 erg/s) with a slope of 0.31 and 0.32, depending on mid-infrared band W1 and W2-band, respectively. We corrected the accretion disk contamination in the observed MIR light flux, obtaining a slightly changed slope of 0.37 and 0.31 for W1 and W2-band lags, respectively. While the new slope is shallower than the value of 0.5 expected from thermal equilibrium model, it is in good agreement with that obtained from the interferometric observations available in the literature. We also found wavelength dependent lags (from K to W1, W2), suggesting a stratified structure of the dust torus, such that emissions in different infrared wavelengths come from the different regions of the torus.

Primary author(s) : Dr. MANDAL, Amit Kumar (Seoul National University, Seoul)

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Presenter(s) : Dr. MANDAL, Amit Kumar (Seoul National University, Seoul)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **135** Type : **Poster**

Investigation on the Narrow Line Seyfert 1 Mrk 335 in an intermediate state, with Chandra/HETGS, NuSTAR and NICER

The Narrow Line Seyfert 1 Mrk 335 has been observed in X-rays since 2000 and has shown to be highly and rapidly variable in flux and spectral shape, due to changes in the structure of the hot corona responsible for the primary X-ray emission via Comptonization. Its complex X-ray spectrum presents interesting features that need to be investigated in different states. While several studies have already been performed in low-flux states and during flares, we focus here on the intermediate-flux state, where previously detected warm absorbers are expected to be more easily detectable. After spending two years in a historically long low-flux state, the source finally became brighter in June-July 2020. On this occasion, we performed simultaneous observations of Mrk 335 with NuSTAR, NICER, and first the first time, Chandra/HETG. We present here our preliminary results regarding the use of NuSTAR observations to constrain the continuum, reflection properties and the broadened Fe-K line, the need for the high-resolution of HETGS to get information on the absorbers structures, and the value of NICER to study the strong soft excess.

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Presenter(s) : BOISSAY-MALAQUIN, Rozenn (NASA Goddard / UMBC, USA)

Session Classification : Poster

Contribution ID : **136** Type : **Contributed talk**

Periodic variability of Stripe 82 quasar light curves

Tuesday, 27 June 2023 18:15 (15)

I am going to present the results of the search for small-amplitude (A_g > 0.03 mag), long-period (100 < P[days] < 600) variability in the SDSS Stripe 82 region. This search led to the discovery of five quasars with apparently periodic light curves. In addition, I will discuss the line profile variability (presumably linked to the change in the phase of the optical light curve) of the MgII emission line of our strongest periodically variable candidate quasar (P=278 days), obtained over the past year. With the data collected so far we were not yet able to exclude the possibility of the object being system of supermassive binary black holes.

Our search was made possible by the precisely calibrated (1%-2%) Stripe 82 photometry in SDSS ugriz bands, which covered a period of approximately 6 years and reached down to r˜22 mag. By analyzing the Lomb-Scargle periodograms, we identified the most promising candidates for periodically variable sources. We then cross-matched these candidates with other surveys across the electromagnetic spectrum (photometry and spectroscopy) to confirm their variability and type. Our analysis was supported by Pan-STARRS and ZTF time series, which provided observational data spanning more than 20 years.

All of the identified candidates were quasars, and the highest-ranked one was flagged as a variable source in the Chandra X-ray catalog. The observed periodic behavior of quasars could be attributed to various factors, such as radio jet precession, tilted or warped accretion disks, tidal disruption events, and other accretion-related effects.

Primary author(s) : Ms. FATOVIC, Marta (Ruder Boskovic Institute); PALAVERSA, Lovro; TISANIC, Kresimir; THANJAVUR, Karun; IVEZIC, Zeljko; KOVACEVIC, Andjelka (Department of Astronomy, University of Belgrade - Faculty of Mathematics, Studentski trg 16, 11000 Belgrade); Prof. ILIC, Dragana (University of Belgrade); Dr. POPOVIĆ, Luka (Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia, Department of Astronomy, Faculty of Mathematics, University of Belgrade, PIFI Research Fellow, Key Laboratory for Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences); YUE, Minghao

Presenter(s) : PALAVERSA, Lovro

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **137** Type : **Poster**

Investigation of a small flaring event in NLS1 galaxy NGC 4051

A detailed broadband spectral and timing analysis of a small flaring event of a120 ks in a narrow-line Seyfert 1 galaxy NGC 4051 using simultaneous XMM-Newton and NuSTAR observations has been performed. The ˜300 ks long NuSTAR observation and the overlapping XMM-Newton exposure were segregated into pre-flare, flare and post-flare segments. We found that during the flare, the NuSTAR count rate peaked at 2.5 times the mean count rate before the flare. We explored the variation of X-ray emission in different time scales using various phenomenological and physical models. The 0.3-50 keV X-ray spectrum of the source can be described by a composite model consisting of a primary continuum, reprocessed emission, warm absorber and ultra-fast outflows. From the spectral analysis, we found that the reflection fraction drops significantly during the flare, accompanied by the increase in the coronal height to ˜12.2 Rg from ˜9.6 Rg (during the pre-flare phase) above the disc. The spectrum became softer during the flare supporting the "softer when brighter" nature of the source. After the alleviation of the flare, the coronal height drops to ˜7.4 Rg and the corona heats up to the temperature of 228 keV. This indicates that there could be inflation of the corona during the flare. We did not find any significant change in the inner accretion disc or the seed photon temperature. These results suggest that the flaring event occurred due to the change in the coronal properties rather than any notable change in the accretion disc.

Primary author(s) : Dr. JANA, Arghajit (Institute of Astronomy, National Tsing Hua University, Hsinchu 30013, Taiwan); Dr. KUMARI, Neeraj; Dr. NANDI, Prantik (Physical Research Laboratory, India); Prof. NAIK, Sachindra (Physical Research Laboratory, India)

Presenter(s) : Dr. KUMARI, Neeraj

Session Classification : Poster

Contribution ID : **138** Type : **Poster**

Jets in the nearby changing-look Seyfert galaxies Mrk 590 and NGC 2617

The dramatic Seyfert type changes might result from intermittent accretion activity. To search for possible ejection activity in the two nearby Changing-look Seyfert galaxies Mrk 590 and Mrk 590, we performed Very Long Baseline Interferometry Observations (VLBI) with the European VLBI Network (Mrk 590). During the talk, we are going to report these milli-arcsecond-resolution studying results. We find that there exist pc-scale faint jets in their radio nuclei. These jets also have partially synchrotron self-absorbed radio cores, indicating the existence for the significant accretion and ejection activity.

Primary author(s) : Dr. YANG, Jun

Presenter(s) : Dr. YANG, Jun

Session Classification : Poster

Contribution ID : **139** Type : **Invited talk**

Review: AGN outflows in X-ray

Friday, 30 June 2023 10:00 (30)

It is clear that an important part of the AGN self sustenance, as well as its connection with the surrounding, is constituted by powerful outflows, detected in a large fraction of objects. Winds can be considered as the messenger in the communication between the AGN and the galaxy. Different wind components co-exist in the same source, often with drastically different properties in terms of carried mass and energy. In this talk I will review X-ray winds and their variability as a function of the central engine flux. Several methods are in place to extract important information on the physics and geometry of the outflowing gas. This in turn provide important diagnostic on AGN feedback.

Primary author(s) : COSTANTINI, Elisa (SRON Netherlands Institute for Space Research)

Presenter(s) : COSTANTINI, Elisa (SRON Netherlands Institute for Space Research)

Session Classification : Outflows

Contribution ID : **141** Type : **Invited talk**

Review: AGN variability with eROSITA

Wednesday, 28 June 2023 12:00 (30)

eROSITA (extended ROentgen Survey with an Imaging Telescope Array), the core instrument on the Russian-German Spektrum-Roentgen-Gamma (SRG) mission has completed 4 scans of the entire sky with unprecedented sensitivity in the 0.2-8 keV energy range. I will present an overview of the instrument capabilities, the current status of the mission, a few selected early science results focusing on the study of the time domain properties of galactic nuclei.

Primary author(s) : Dr. MERLONI, Andrea

Presenter(s) : Dr. MERLONI, Andrea

Session Classification : Current and Future Surveys

Contribution ID : **142** Type : **Invited talk**

Review: The Physics of Accretion and Outflow in Tidal Disruption Events

Thursday, 29 June 2023 12:00 (30)

Tidal disruption events of stars provide unique opportunities for probing massive black holes in centers of galaxies. Furthermore, these events are great laboratories for studying black hole accretion and outflow physics. In this talk, I will first give a theoretical overview of the accretion, wind and jet physics tidal disruption events. Then I will discuss our latest discoveries on using general relativistic magnetohydrodynamic and radiative transfer simulations to understand the accretion disk and outflow in tidal disruption events and connect theory to the observed signatures.

Primary author(s) : Prof. DAI, Jane (The University of Hong Kong)

Presenter(s) : Prof. DAI, Jane (The University of Hong Kong)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **144** Type : **Invited talk**

Review: Changing-look AGN

Thursday, 29 June 2023 09:30 (30)

AGN are known to show flux variability over all observable timescales and across the entire electromagnetic spectrum. Over the past decade, a growing number of sources have been observed to show dramatic flux and spectral changes, both in the X-rays and in the optical/UV. Such events, commonly described as "changing-look AGN", can be divided into two well-defined classes. Changing-obscuration objects show strong variability of the line-of-sight column density, mostly associated with clouds or outflows eclipsing the central engine of the AGN. Changing-state AGN are instead objects in which the optical/UV continuum emission and broad emission lines appear or disappear, and are typically triggered by strong changes in the accretion rate of the supermassive black hole. In my talk I will review our current understanding of these objects, and then focus on a few recent X-ray monitoring campaigns of Changing-state AGN.

Primary author(s) : Dr. RICCI, Claudio (Universidad Diego Portales)

Presenter(s) : Dr. RICCI, Claudio (Universidad Diego Portales)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **145** Type : **Contributed talk**

New Types of Flares from Accreting Supermassive Black Holes

Thursday, 29 June 2023 10:00 (15)

A growing number of transient phenomena in galaxy nuclei have recently begun to shed new light on SMBH demographics and the physics of gas accretion onto these objects, tracing events where this accretion has drastically intensified, diminished, and/or otherwise disturbed. I will present recent results regarding some of these new classes of high-variability phenomena, focusing on insights gained thanks to responsive, multi-wavelength follow-up observations. These include "changing look" AGN that occur on surprisingly short timescales (several weeks), and for which we have strong evidence for the nature of the transition (i.e., accretion vs. obscuration); and other, yet poorly understood flaring AGN with broad Bowen fluorescence emission features, driven by extreme UV radiation that appears within weeks but lasts for well over a year. While these events observationally differ from the tidal disruption events known to date, the physics behind them may be interlinked. Together, these extreme events can greatly advance our understanding of SMBH accretion, teach us how and why SMBHs turn their accretion "on" and "off", and reveal super-Eddington accretion. I will finally mention how new surveys, such as the SDSS-V, will discover & survey many more SMBH-related transients.

Primary author(s) : Dr. TRAKHTENBROT, Benny (Tel Aviv University)

Presenter(s) : Dr. TRAKHTENBROT, Benny (Tel Aviv University)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **146** Type : **Contributed talk**

Modeling the effects of quasar variability source geometry on light curves

Friday, 30 June 2023 15:45 (15)

Quasar variability is often modeled simplistically as originating from a point-like lamp post geometry with a damped random walk time dependence. We create more realistic simulations of variability propagation through quasar structure using a flexible and physically motivated quasar model that incorporates lensing by the SMBH, disk and broad-line reprocessing, and extended geometry of the variability source. Using this model, we derive realistic transfer functions and simulate LSST-like multi-band light curves for a wide range of quasar structure parameters and variability source geometries. We use these to explore the degree to which deviations from the simplistic lamp post models can be determined in upcoming time-domain surveys. We also analyze light curves from SDSS and other existing surveys to make preliminary constraints on the validity of these models.

Primary author(s) : IERACE, Bridget (CUNY/AMNH)

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Presenter(s) : IERACE, Bridget (CUNY/AMNH)

Session Classification : Methods and techniques

Contribution ID : **147** Type : **Poster**

Probing the origin of broad line region by reverberation mapping and multi-wavelength observations of an extremely variable quasar

While the unified model of quasar structure provides a concise description of diverse spectra, the physical origins of components (e.g., broad line region, dust torus, and narrow line region) are unresolved. To learn more about the structure of quasars, we have chosen to study Changing-State Quasars (also known as Changing-Look Quasars) as they offer the opportunity to observe structural changes that occur during state transitions. This can give us insight into the origins of quasar structure, including the BLR. We aimed to understand the central core structure of one of the Changing-State Quasar and how it changes before and after the state transition. As the research target, we selected SDSS J125809.31+351943.0, which exhibited one of the most significant variations ever (Nagoshi+21). We performed reverberation mapping with optical spectroscopy to investigate the structure of the broad line region and to measure the black hole mass. We also measured the time-lag between the WISE light curve and optical light curve to estimate the size of the dust torus. In addition, we compared optical to X-ray spectral indices ($\alpha_{\rm ox}$) before and after the state transition to investigate the structure difference of the accretion disk. The results of the reverberation mapping show that the Eddington ratio crossed the value of 0.01 before and after state transition for the constant black hole mass of $10^{9.46^{+0.15}_{-0.19}}\mathrm{M}_{\odot}$. The variations in $\alpha_{\rm ox}$ and the Eddington ratio were consistent with those predicted from the instability of the accretion disk caused by hydrogen ionization. In the viewpoint of broad line region, we confirmed the existence of two distinct rotating/inflowing components located near the dust torus. We discuss the origin of these line-emitting regions. We suggest that these components originate from rotating/inflowimg gases located near the dust torus generated by different processes.

Primary author(s) : Dr. NAGOSHI, Shumpei (Kyoto University)

Presenter(s) : Dr. NAGOSHI, Shumpei (Kyoto University)

Session Classification : Poster

Contribution ID : **149** Type : **Contributed talk**

Supermassive black hole binaries and quasar broad emission line variability

Thursday, 29 June 2023 17:30 (15)

Supermassive black hole binaries are thought to be an inevitable product of the prevailing galaxy evolution scenarios where most massive galaxies host a central black hole and undergo mergers over cosmic time. The early stages of this process have been observed in the form of interacting galaxy pairs and widely separated dual quasars, but the close, gravitationally bound binaries that are expected to follow have so far eluded observation. The detection of this population is important because at the smallest separations they become bright sources of low-frequency gravitational waves and are prime targets for multi-messenger detections. One approach to search systematically for close supermassive black hole binaries among quasars is based on the hypothesis that the secondary black hole in the system is feeding and the resulting emission lines will be doppler shifted due to its orbital motion. Binary candidates identified via this method are therefore selected from nearby quasars via substantial (>1000 km/s) shifts of the broad H-beta lines relative to the systemic redshift. One key test of this search is an ongoing spectroscopic monitoring campaign to look for signs of bulk motion of the quasar indicative of orbital motion. I will describe the observational research program that I have been leading, including our most compelling candidates and efforts to evaluate the credentials of these candidates in the face of quasar variability.

Primary author(s) : RUNNOE, Jessie (Vanderbilt University)

Presenter(s) : RUNNOE, Jessie (Vanderbilt University)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **150** Type : **Contributed talk**

Extracting physical parameters of SMBH accretion by modeling the X_ray spectra of TDE.

Thursday, 29 June 2023 12:30 (15)

The disruption and subsequent accretion of a star by a super-massive black hole (SMBH) provides an excellent laboratory to study a broad range of accretion conditions over timescales as short as months or a few years. We show how a physical model of a relativistic thin accretion disc, applied to the X-ray spectra of a sample of 19 tidal disruption events (TDE) in the high-accretion thermal phase, can yield the black hole mass and inner radius of the disc. From this study we offer a possible solution for the problem of low apparent total mass accretion in TDE systems and perform a sanity check on the hypothesis that the peak optical/UV emission in TDEs is due to the reprocessing of X-ray radiation.

When the accretion rate in a TDE drops well below the Eddington limit, the spectrum is commonly observed to develop a hard X-ray tail, believed to be due to the Compton up-scattering of disc photons by a warm electron cloud. We show that this component develops very rapidly in at least one source and use this to constrain the mechanism responsible for the creation of the Comptonisation zone. Finally we present new data on a further interesting extra-galactic, hard X-ray transient, providing strong support that it was also caused by a TDE.

Primary author(s) : SAXTON, Richard (Telespazio for ESA, ESAC, Madrid, Spain); Dr. MUMMERY, Andrew (Oxford Theoretical Physics); Dr. WEVERS, Thomas (European Southern Observatory); Dr. LI, Dongyue (NAOC); Dr. GIUSTINI, Margherita (Centro de Astrobiología (CAB), CSIC-INTA, Spain); Dr. MINIUTTI, Giovanni (Centro de Astrobiología (CAB), CSIC-INTA); Dr. KAJAVA, Jari (SERCO for ESA)

Presenter(s) : SAXTON, Richard (Telespazio for ESA, ESAC, Madrid, Spain)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **152** Type : **Poster**

Intra-night optical variability study of radio-flared radio-quiet narrow-line Seyfert 1 galaxies

AGN variability on minutes to hour-like timescales in the optical waveband is termed as intra-night optical variability (INOV). Such variations are used as an alternative tool to indirectly verify the presence of jets in AGNs. Here, we report the first attempt to systematically characterize INOV for a sample of radio-quiet narrow-line Seyfert1 galaxies (RQ-NLSy1s) that had shown multiple flaring at 37 GHz in the radio observations of the Metsahovi radio telescope but no jet counterparts in the recent radio observations of Karl G. Jansky Very Large Array (JVLA) at 1.6, 5.2, and 9.0 GHz. Thus, It is unclear if these NLSy1s possess relativistic jets that cause flaring at 37 GHz. A total of 28 intra-night sessions, each lasting >3 h was conducted for the INOV study of this sample. In our analysis, special care has been taken to address the possible effect on the differential light curves, of any variation in the seeing disc during the session, since that might lead to spurious claims of INOV from such AGN due to the possibility of a significant contribution from the host galaxy to the total optical emission. From our observations, a duty cycle (DC) of INOV detection in the RQ-NLSy1s is estimated to be around 30 percent, which is comparable to that known for blazars. This suggests that a few of the sources from this sample possess relativistic jets even though being radio-quiet. We also briefly discuss the possible mechanisms for the non-detection of relativistic jets in their JVLA observations.

Primary author(s) : Dr. VINEET , Vineet (Physical Research Laboratory); Dr. VEERESH, Veeresh (Physical Research Laboratory)

Presenter(s) : Dr. VINEET , Vineet (Physical Research Laboratory)

Session Classification : Poster

Contribution ID : **153** Type : **Contributed talk**

Time Dependent Line Driven Disc Winds - X-ray Irradiation

Friday, 30 June 2023 10:45 (15)

Line driving is a promising explanation for AGN winds as it provides both a launching mechanism and an explanation for the absorption and emission lines in spectra. As the community moves towards multi-wavelength and multi-epoch observations, our modelling of AGN systems must likewise follow suit to leverage these new capabilities. For line driving to be a viable acceleration mechanism two conditions must exist in the wind 1) The gas must be sufficiently, though not overly, ionized by X-rays, so that the gas can interact with the UV 2) The UV flux incident on the gas must be high enough to transfer sufficient momentum to overcome gravity. We present novel simulations of AGN disc winds using time-dependent, multi-frequency radiation hydrodynamics focusing on the problem of gas ionization, where we model both the X-ray and UV radiation fields. We consider a suit of models for gas/X-ray interactions and identify the conditions on scattering and absorption opacities where wind self-shielding can operate and allows line driving to launch winds.

Primary author(s) : DYDA, Sergei (University of Virginia); Prof. DAVIS, Shane (University of Virginia); Prof. PROGA, Daniel (University of Nevada Las Vegas)

Presenter(s) : DYDA, Sergei (University of Virginia)

Session Classification : Outflows

Contribution ID : **154** Type : **Poster**

X-ray Vision on NGC6300: another changing-look AGN?

Obscuration in active galactic nuclei (AGN) has been largely studied all over the electromagnetic spectrum. It is commonly accepted that the obscuration is caused by a “dusty torus”, i.e., a distribution of molecular gas and dust located at ~1–10 pc from the accreting supermassive black hole (SMBH). While the existence of this obscuring material is universally accepted, its geometry and chemical composition still remained unknown. Several works reported observational evidence favoring a “clumpy torus” scenario, where the obscuring material is distributed in clumps formed by optically thick clouds. If the obscuring torus is indeed inhomogeneous, one would expect to observe significant variability in the torus line-of-sight column (l.o.s.) density (NH,l.o.s.) and even, in some cases, a “changing look” scenario, i.e., a transition from a Compton-thick (CT-) state (where NH,l.o.s.>10ˆ24 cmˆ−2) to a Compton-thin or vice-versa. Within this framework, I will present our analysis of NGC6300, a local Seyfet-2 AGN, using multi-epoch observations over a span of 13 years (2007-2020) using Suzaku, Chandra and NuSTAR. We have used physically motivated uniform torus model- borus02, and clumpy torus models- UxClumpy and Xclumpy to produce a comprehensive and systematic analysis of the obscuring medium. Even though we do not find any changing-look nature for NGC6300, but the recent Chandra observation of 2020 showed a considerable flux dip (˜60%) confirming the variable nature and laying the ground for follow-up X-ray observations for this source. Finally, I will conclude on using multi-component models to analyse the AGN SED in mid-IR band and producing a joint analysis of mid-IR SED-derived view of the obscuring torus with the X-ray perspective.

Primary author(s) : SENGUPTA, Dhrubojyoti (University of Bologna, INAF-OAS Bologna); Mrs. PIZZETTI, Andrealuna (Clemson University); Dr. TORRES-ALBA, Nuria (Clemson University); Dr. MARCHESI, Stefano (INAF-OAS, Bologna); Prof. VIGNALI, Cristian (University of Bologna, INAF-OAS Bologna)

Presenter(s) : SENGUPTA, Dhrubojyoti (University of Bologna, INAF-OAS Bologna)

Session Classification : Poster

Contribution ID : **155** Type : **Contributed talk**

Hydrodynamical simulations of the variable accretion on to our closest SMBH

Tuesday, 27 June 2023 12:15 (15)

Sgr A*, located only 8 kpc away, allows us to study in detail the accretion process on to a supermassive black hole. Direct observations show that the black hole luminosity varies on different time-scales, but remains extremely dim, despite the (disputed) presence of a cold gaseous disc. However, indirect evidence reveals that it was several orders of magnitude brighter just a few hundred years ago, and perhaps an AGN a few million years in the past. Unlike any other supermassive black hole, in our Galactic centre we can directly observe the source of the material feeding the accretion, which in this case corresponds to a few dozen young, massive stars, with powerful stellar winds. After reviewing the observed variability, I will describe our hydrodynamical models of the gas surrounding Sgr A*, originating from the observed stars, with known orbits and stellar wind properties. Our simulations show that these winds can naturally account for the formation of both the hot, inefficient accretion flow and the cold disc. Moreover, the stellar orbits, and the formation of cold clumps and streams, make the accretion vary on time-scales of decades to millennia, potentially explaining the observed behaviour.

Primary author(s) : Prof. CUADRA, Jorge (Universidad Adolfo Ibáñez); Dr. CALDERÓN, Diego (Universität Hamburg); Dr. RUSSELL, Christopher (University of Delaware)

Presenter(s) : Prof. CUADRA, Jorge (Universidad Adolfo Ibáñez)

Session Classification : Accretion and variability theory

Contribution ID : **156** Type : **Contributed talk**

Studying Quasar accretion discs with massive optical variability surveys

Tuesday, 27 June 2023 16:15 (15)

Quasars optical variability gives us clues to understand the accretion disc around supermassive black holes. We can expect variability properties to correlate with the main physical properties of the accreting black hole, i.e., its mass and accretion rate. It has been established that the relative amplitude of optical variability anti-correlates with the accretion rate and luminosity.The dependence of the variance on black hole mass has remained elusive, and contradicting results, including positive, negative, or no correlation, have been reported. In this work, we show that the key to these contradictions lies in the timescales of variability studied (e.g., the length of the light curves available). By isolating the variance on different timescales as well as mass and accretion rate bins we show that there is indeed a negative correlation between black hole mass and variance and that this anti-correlation is stronger for shorter timescale fluctuations. The behavior can be explained in terms of a universal variability power spectrum for all quasars, resembling a broken power law where the variance is constant at low temporal frequencies and then drops continuously for frequencies higher than a characteristic frequency f_b, where f_b correlates with the black hole mass. Furthermore, to explain all the variance results presented here, not only the normalization of this power spectrum must anti-correlate with the accretion rate, but also the shape of the power spectra at short timescales must depend on this parameter as well. In this talk I will present the possible interpretations of the dependence of power spectral shape on both parameters as well as the data supporting the results.

Primary author(s) : Prof. ARÉVALO, Patricia (Instituto de Física y Astronomía, Universidad de Valparaíso); Prof. LIRA, Paulina (Universidad de Chile); Dr. SÁNCHEZ-SÁEZ, Paula (ESO); PATEL, Priyanjali (Universidad de Chile); LÓPEZ-NAVAS, Elena (Universidad de Valparaíso); Dr. CHURAZOV, Eugene (MPA); Dr. HERNÁNDEZ-GARCÍA, Lorena (Universidad de Valparaíso)

Presenter(s) : Prof. ARÉVALO, Patricia (Instituto de Física y Astronomía, Universidad de Valparaíso)

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **157** Type : **Invited talk**

Review: Extreme variability around supermassive black holes: Quasi Periodic Eruptions

Thursday, 29 June 2023 15:15 (30)

Serendipitously discovered at the end of 2018 in the nucleus of the galaxy GSN 069, X-ray quasi-periodic eruptions (QPEs) are a new extreme-variability phenomenon associated with supermassive black holes. QPEs typically appear as sharp and intense burst of X-ray emission, with a thermal-like spectrum with a temperature $kT \sim 150$ eV over a much more stable and cooler quiescent level; they last about one hour and repeat quasi-periodically every few hours, carrying a few 10^{42-43} erg s^{-1} at each burst. X-ray QPEs have been securely detected in the nuclei of several galaxies since their discovery, all with low-mass supermassive black holes ($M_{BH} < 10^7 M_{\odot}$) and different levels of nuclear activity. In this talk I will review the general properties of QPEs and their variegate phenomenology in the QPE-sources (up to 7) detected so far. I will then discuss the physical scenarios invoked to explain this new and puzzling extreme-variability X-ray phenomenon, as well as the more and more evident physical connection of QPEs with tidal disruption events (TDEs) in low-mass galaxies.

Primary author(s) : Dr. GIUSTINI, Margherita (Centro de Astrobiología (CAB), CSIC-INTA, Spain); MINIUTTI, Giovanni (Centro de Astrobiología (CAB), CSIC-INTA); SAXTON, Richard (Telespazio for ESA, ESAC, Madrid, Spain); Dr. ARCODIA, Riccardo (MIT Kavli Institute for Astrophysics and Space Research, Cambridge (MA), USA)

Presenter(s) : Dr. GIUSTINI, Margherita (Centro de Astrobiología (CAB), CSIC-INTA, Spain)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **158** Type : **Poster**

Variability, propagating fluctuations and epicyclic motion: stochastic simulations of accretion disks in 2D

Accretion onto black holes and other compact objects occurs across a wide range of scales. Despite the diversity in the physics involved, the variability shows a remarkable similarity in its properties. The theory of propagating fluctuations, in which random fluctuations within an accretion disk travel inwards and combine, has long been used to explain this variability. Recent numerical work has expanded on the extensive analytical literature but has been restricted to using the 1D diffusion equation for modelling the disk behaviour. In this talk, I present a novel numerical approach for 2D (vertically integrated), stochastically driven α-disk simulations, generalising existing 1D models. This is achieved through defining α as a function of a stochastic random variable β which is advected as a tracer field and stochastically evolved in time according to an Ornstein-Uhlenbeck process. I show that these simulations reproduce a wide range of observational features of AGN, including the linear rms-flux relationship, a broadband power spectrum which is best fit with a broken power-law and lags between emission in different energy bands. Additionally, there are two key differences between the existing theory of propagating fluctuations and our new 2D simulations. Firstly, we find that the presence of epicyclic motion in 2D (which cannot be captured within the 1D diffusion equation) has an important impact on local disk dynamics. Secondly, the light-curves are only log-normal when the disk is sufficiently thick, with thinner disks instead showing a normal distribution. We also find that these thinner disks are significantly less variable than thicker ones. I further show that the break frequency in the luminosity power spectrum is strongly dependent on the driving timescale of the stochastic evolution of the β parameter within the disk, providing a possible observational signature for probing the magnetorotational instability (MRI) dynamo.

Primary author(s) : TURNER, Samuel G D (University of Cambridge); Prof. REYNOLDS, Christopher S (Institute of Astronomy, University of Cambridge and University of Maryland, College Park and Joint Space-Science Institute, Maryland)

Presenter(s) : TURNER, Samuel G D (University of Cambridge)

Session Classification : Poster

Contribution ID : **160** Type : **Contributed talk**

The First Sample of ”Changing Look” AGN in SDSS-V

Thursday, 29 June 2023 10:30 (15)

Recent advances in time-domain surveys have revealed dramatic changes to SMBH accretion and AGN appearance on surprisingly short timescales. Among those, changing-look AGNs (CL-AGNs) show the (dis)appearance of broad emission lines and/or the quasar-like continuum, on timescales of years and sometimes even months. These dramatic changes may be driven by significant changes to the accretion flow and/or circumnuclear gas, and can therefore provide key novel insights into these physical components. In this talk I will present the largest sample of (candidate) CL-AGNs to date, with >100 sources, obtained from the first year of observations by the recently launched SDSS-V project, and assisted by follow-up observations with HET, Palomar, and LCOGT. Our sample covers a redshift range of $0.06 < z < 2.5$ and rest-frame transition timescales lasting from 2 months and up to 19 years. Our preliminary analysis shows that CL-AGNs occur at systems with relatively low Eddington ratios, but with no preference for certain BH masses or luminosities. I will highlight a particularly extreme CL-AGN, varying on timescales of <2 months, whose optical spectrum and lightcurve are most likely driven by variable obscuration, on unprecedentedly short timescales. Our large sample will allow us to gain insights into the physical mechanisms of CL-AGNs, with potential implications for the unified AGN model and thus for AGN demographics.

Primary author(s) : ZELTYN, Grisha

Presenter(s) : ZELTYN, Grisha

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **161** Type : **Contributed talk**

Fantastic fits of AGN spectra with FANTASY: case-study of SDSS-RM spectra

Friday, 30 June 2023 16:15 (15)

We present a new tool FANTASY (Fully Automated pythoN Tool for Agn Spectral analYsis) for multicomponent fitting of active galactic nuclei (AGN) spectra in the optical and near infrared wavelength band. Spectra are modeled by simultaneously fitting the underlying broken power-law continuum, predefined emission line (narrow, broad, coronal, etc.) lists, and an Fe II model, which is here extended to cover the wavelength range from 3700 to 11000A. The Fe II model, founded solely on atomic data, effectively describes the strong emission of the complex iron ion in the vicinity of the Hγ and Hβ lines, but also near the Hα line. Here we present a case study of the application of FANTASY code on SDSS-RM spectra with S/N>20, with the aim to study the variability properties of Balmer lines, as well as of Fe II emission. One interesting finding is that when Fe II emission is present near Hbeta, it is also detected redward from Hα, potentially contaminating the broad Hα line wings. We show that the FANTASY code is well optimised for bulk fitting of AGN type 1 spectra from SDSS, as it is flexible and easy to use, thus showing great potential for AGN spectral analysis in the coming spectral surveys.

Primary author(s) : Prof. ILIC, Dragana (University of Belgrade); Dr. RAKIC, Nemanja (University of Banja Luka); Dr. POPOVIĆ, Luka (Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia, Department of Astronomy, Faculty of Mathematics, University of Belgrade, PIFI Research Fellow, Key Laboratory for Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences)

Presenter(s) : Prof. ILIC, Dragana (University of Belgrade)

Session Classification : Methods and techniques

Contribution ID : **162** Type : **Poster**

Variability of Local X-ray Selected AGN

Investigations into the connections between the variability parameters and the central engine over the past decades have generally relied on large ensemble samples of distant (10^8-10^10 M⊠) quasars or intense high-cadence monitoring of a very limited sample of local AGN. Here we systematically characterize the optical variability for the more modest supermassive black holes (10^6-10^8 M⊠) among the BASS AGN sample using ZTF g and r bands, and compare this to samples of more massive central engines to study correlations between fundamental parameters (e.g black hole mass, accretion rate, wavelength dependence, accretion disk size). We model the variability with several metrics including CARMA(2,1) DHO models [Brockwell+01]. After obtaining best-fit parameters and error distributions, we retrieve characteristic time scales and amplitudes of the variability, evaluate them with the Monte Carlo Markov chain and study their correlation with the black hole mass. We compare our results with wavelet analysis to test the ranges of the said features.

Primary author(s) : BEHAR, Priscilla (PUC Chile); Prof. BAUER, Franz

Presenter(s) : BEHAR, Priscilla (PUC Chile)

Session Classification : Poster

Contribution ID : **163** Type : **Poster**

Photometric Reverberation Mapping

Reverberation mapping (RM) is the main tool by which spatially unresolved components of accreting black holes may be probed. To date, the size of the broad-line region in ˜100 quasars has been successfully measured using RM. Here we outline the concept of photometric RM, implement the multivariate correlation-function formalism and present new results for a sample of around 40 quasars. We argue that this approach can efficiently compete with the traditional (spectroscopic) approach to RM, and may be easily implemented at a tiny fraction of the cost.

Primary author(s) : Dr. SOBRINO FIGAREDO, Catalina (University of Haifa)

Presenter(s) : Dr. SOBRINO FIGAREDO, Catalina (University of Haifa)

Session Classification : Poster

Contribution ID : **164** Type : **Poster**

Self-Consistent Modelling of AGN

Large scale surveys such as the Legacy Survey of Space and Time will soon discover and monitor 1000's of new strongly lensed Active Galactic Nuclei (AGN). These surveys offer the potential to extract the rich structural information encoded in the intrinsic fluctuations of these quasars via reverberation mapping. However, to fully realize this potential we need more realistic and detailed simulations of AGN variability. We present a new model for continuum and broad-line reverberation through a physically motivated but flexible model of AGN structure and kinematics. This model incorporates all relativistic effects, including lensing by the SMBH, a flexibly parameterized accretion disk and broad-line flow, continuum reprocessing by disk, secondary scattering by the broad line region, and arbitrary geometry and time-dependence for the variability source. The resulting transfer functions contain nuanced detail about the AGN central engine, and can be derived without explicit integral evaluations, enabling a highly flexible simulation of intrinsic variability.

Primary author(s) : BEST, Henry (CUNY)

Co-author(s) : O'DOWD, Matthew (CUNY); FAGIN, Joshua (CUNY); CHAN, James (CUNY/AMNH); IERACE, Bridget (CUNY/AMNH)

Presenter(s) : BEST, Henry (CUNY)

Session Classification : Poster

Contribution ID : **165** Type : **Invited talk**

Review: AGN Optical/UV Variability: pleasures and pains

Tuesday, 27 June 2023 15:00 (30)

Variability characterizes AGN at all wavelengths and is observed both in continuum and line emission. My talk aims at giving an overview of AGN optical/UV variability, focusing on the main results and challenges from the past decades.

Primary author(s) : Dr. DE CICCO, Demetra (Università degli Studi di Napoli "Federico II")

Presenter(s) : Dr. DE CICCO, Demetra (Università degli Studi di Napoli "Federico II")

Session Classification : UV/Optical/IR Continuum variability

Contribution ID : **167** Type : **Contributed talk**

Flat Spectrum Radio Quasars: 10 years of variability in gamma-ray

Friday, 30 June 2023 12:15 (15)

I will show the results of the study of variability for a sample of more than 300 FSRQ in gamma-ray, focusing on waiting time between flares (L. Pacciani, A&A, 2022, 658, 164), and on flares luminosity and duration. The investigation of waiting times revealed that gamma-ray activity can be modeled with overlapping bursts of flares, with flares uniformly distribuited within each burst, and bursts uniformly distribuited with a typical rate of 0.6/y. Morerover, a statistically relevant fast component with timescale of order of days is revealed. From this result, constraints on flares emission mechanisms were derived. Timescales derived for FSRQ variability is very similar to the findings of Ivezic & MacLeod 2013, and of Burke 2021 for the damping timescale found in optical for SMBH of 10ˆ8-10ˆ9 solar masses. Moreover, Kelly et al. (2009) aobserved that radio-loud quasars show an excess optical variability for timescales below 1 d, with a white noise PSD. These similarities suggest a common origin for such a variability.

Primary author(s) : PACCIANI, Luigi (IAPS-INAF)

Presenter(s) : PACCIANI, Luigi (IAPS-INAF)

Session Classification : Radio loud AGN

Contribution ID : **168** Type : **Contributed talk**

Identifying low accretion rate AGN and studying their X-ray variability with the EPIC XMM Outburst Detector Ultimate System (EXODUS)

Monday, 26 June 2023 18:00 (15)

Temporal variability of flux across the electromagnetic spectrum is a commonly observed phenomenon in Active Galactic Nuclei (AGN), however the phenomenon is not well studied in low accretion rate AGN, primarily due to difficulties identifying them in X-ray catalogues due to their lower luminosity. In this work, we use our algorithm EXODUS, which searches for variability in the whole of *XMM-Newton*'s EPIC field of view and is agnostic of source detection and the number of counts. It accomplishes this by binning the observations into short time windows and comparing the pixel counts per window to the median pixel counts to detect variable sources within the observation, making EXODUS ideal for studying faint rapid X-ray transients. We apply EXODUS to all of the observations that comprise the 4XMM-DR11 catalogue to create a reliable subset of low Eddington ratio AGN. Understanding these AGN helps us to develop a more complete framework constraining the presence/absence of the corona from the hardness/softness of spectra during the low accretion phase. Additionally, we measure black hole masses, variability timescales, and the prominence of their coronal/disc emission by studying the effect of the different modes of AGN accretion on line-emitting gas. We compare the results of this study with those of our previous X-ray studies on moderate accretion rate AGN selected from the BAT AGN Spectroscopic Survey sample.

Primary author(s) : Dr. GUPTA, Maitrayee (Institute for Research in Astrophysics and Planetology (IRAP), CNRS, Toulouse, France); Dr. PANDA, Swayamtrupta (Laboratório Nacional de Astrofísica, Itajubá, Brazil); Prof. WEBB, Natalie (Institute for Research in Astrophysics and Planetology (IRAP), CNRS; Universite de Toulouse, CNES, Toulouse, France)

Presenter(s) : Dr. GUPTA, Maitrayee (Institute for Research in Astrophysics and Planetology (IRAP), CNRS, Toulouse, France)

Session Classification : X-ray continuum variability

Contribution ID : **169** Type : **Poster**

Extreme X-ray variability events of a weak-line quasar

We report the discovery of extreme X-ray variability events of the weak-line quasar SDSS J1539+3954 at z = 1.935. Before the X-ray flux rise (by a factor of > 20) observed in 2019, SDSS J1539+3954 appeared X-ray weak compared with the expectation from its ultraviolet (UV) flux; after the rise, the ratio of its X-ray flux and UV flux was consistent with the majority of the AGN population. A flux drop by a factor of > 9 was observed nine months after the flux rise, and SDSS J1539+3954 became X-ray weak again. The HET spectra of SDSS J1539+3954 that are taken contemporaneously with X-ray observations show that its UV continuum level remains generally unchanged despite the dramatic variation in the X-ray flux, and its C iv emission line remains weak. The dramatic change only observed in the X-ray flux is consistent with a shielding model, where a thick inner accretion disk can block our line of sight to the central X-ray source. This thick inner accretion disk can also block the nuclear ionizing photons from reaching the high-ionization broad emission-line region, so that weak high-ionization emission lines are observed. Under this scenario, the extreme X-ray variability events may be caused by slight variations in the thickness of the disk across our line of sight.

Primary author(s) : Dr. NI, Qingling

Presenter(s) : Dr. NI, Qingling

Session Classification : Poster

Contribution ID : **170** Type : **Contributed talk**

AGN in the La Silla QUEST Variability Survey

Wednesday, 28 June 2023 11:45 (15)

The La Silla QUEST (LSQ) supernova survey ran for 6 years on the ESO 1m Schmidt telescope at La Silla Chile, using a large CCD array to replace the photographic plate of the Schmidt. The survey imaged ˜1000 degrees twice per night using a single broad V band filter, covering a total area of ˜25,000 square degrees from declination ˜ -80 to +25 degrees. The survey magnitude limit is V˜21 in a single 60 second exposure, with an average of ˜200 visits for any given patch of sky and over one thousand square degrees of sky covered by more than 1000 visits. Systematic photometric errors from the current differential photometry pipeline are at the 5-10 mmag level for bright point sources on a good night, with further improvements expected. The QUEST V filter can be absolutely calibrated against SDSS and PanSTARRS g+r data at the percent level, enabling LSQ, for example, to extend in time the SDSS Stripe 82 variability survey. Although principally designed to find supernovae, the strict survey cadence provides good logarithmic time coverage on timescales from ˜30 minutes to ˜years, ideal for probing AGN variability and constraining, for example, the parameters of a Damped Random Walk model. We present some highlights of LSQ AGN science. The LSQ dataset should prove useful as a training set to prepare for LSST. Over 1 million LSQ-selected AGN candidates will also be followed up by the upcoming ESO 4MOST survey.

Primary author(s) : COPPI, Paolo (Yale University); ON BEHALF OF THE LA SILLA QUEST SURVEY TEAM

Presenter(s) : COPPI, Paolo (Yale University)

Session Classification : Current and Future Surveys

Contribution ID : **171** Type : **Poster**

TEPID: Time Evolving PhotoIonisation Device for ionised gas, from the optical up to the X-rays

Photoionised gas at all scales is ubiquitously observed in AGNs, from the optical up to the X-rays. Its density, geometry, velocity represent a unique probe of the innermost accretion disc-scale, as well as on the feeding and feedback connecting the AGN to the host environment.

However, current photoionisation codes usually assume time-equilibrium and, thus, cannot self-consistently model the gas response to a time-variable (or transient) ionising source, as for most of the AGNs, and leads to incorrect results when fitting emission and absorption spectra. Moreover, gas density and distance are degenerate at equilibrium and, thus, the outflows energy and mass rates can be determined only with order-of-magnitude uncertainties.

To gain more insights from current observations, especially in the UV (HST) and in the X-rays (XMM-Newton, Chandra), and get ready for the incoming XRISM X-ray telescope, we developed one of the first Time Evolving Photo-Ionisation Device (TEPID), which follows the gas ionisation in response to a (time-varying) luminosity source. The code is highly flexible and can model any astrophysical scenario, from variable AGNs to GRBs and diffuse nebulae. We are now analysing archival XMM-Newton observations of time-variable AGN absorbers, with a particular focus on those that will be observed in the Performance Verification phase of XRISM.

Primary author(s) : LUMINARI, Alfredo (INAF - IAPS, Italy)

Presenter(s) : LUMINARI, Alfredo (INAF - IAPS, Italy)

Session Classification : Poster

Contribution ID : **173** Type : **Contributed talk**

Late-time X-ray Rebrightening vs. Early Double-peaked Balmer Emission: Investigating Disk Formation in Nuclear Transient AT2020nov

Thursday, 29 June 2023 15:45 (15)

We present the photometric and spectroscopic analysis of a new nuclear transient AT2020nov, an event that shows properties consistent with both TDEs and active galactic nuclei (AGN). Observations in the X-ray show late-time flaring, coincident with a minor re-brightening in the optical/UV. Evolution in the X-ray hardness ratio follows a trend from hard to soft, suggesting a change in the accretion behavior with time. Optical spectroscopy taken both before and after the light curve peak show a blue continuum, with resolved double-peaked Balmer emission and possible Bowen Fluorescence features. The discrepancy between the X-ray and UV/optical photometry indicates that the radiation sources are initially uncorrelated, with emission arising from physically distinct components. This implies a scenario in which the optical/UV peak is powered by collisions in the debris streams of a circularizing accretion disk, while the late-time X-ray and optical/UV bump result from the enhanced accretion rate of the circularized disk. However, modeling of the double-peaked Balmer features in the spectra with an elliptical accretion disk indicates that the disk formed early and fast, inconsistent with circularization occurring at late times. In this talk, I'll discuss how this new event fits into the landscape of nuclear transients generally, and TDEs/AGN specifically.

Primary author(s) : EARL, Nicholas (University of Illinois at Urbana-Champaign)

Presenter(s) : EARL, Nicholas (University of Illinois at Urbana-Champaign)

Session Classification : Extreme variability: CL AGN, TDEs and binary SMBHs

Contribution ID : **174** Type : **Contributed talk**

X-ray polarimetry of Seyferts and the nature of the hot corona

Monday, 26 June 2023 18:30 (15)

We present the first X-ray polarimetric measurements of three Seyfert 1 galaxies with IXPE, the NASA/ASI mission operating as of December 2021. The results allow us to directly constrain the geometrical shape of the hot corona for the first time. We discuss the implications for the physical interpretation of X-ray variability in these sources.

Primary author(s) : Dr. URSINI, Francesco

Presenter(s) : Dr. URSINI, Francesco

Session Classification : X-ray continuum variability

Contribution ID : **175** Type : **Contributed talk**

Continuous X-ray monitoring of the south ecliptic pole with eROSITA

Wednesday, 28 June 2023 13:00 (15)

The eROSITA all-sky surveys (eRASS) continuously scan the sky along great circles crossing the ecliptic poles. This scanning strategy covers the full sky every six months and visits the ecliptic poles every four hours, leading to much longer exposure time and much higher cadence at the ecliptic poles than the majority of the sky. Between Dec. 2019 and Feb. 2022, the eRASS surveys scanned the full sky more than four times and observed the ecliptic poles more than 4600 times, with a total exposure of more than 160ks at the ecliptic poles. Because of the long exposure near the confusion limit of eROSITA, we treated the region within 3 degrees of the south ecliptic pole (SEP) separately from the main part of the eRASS surveys and detected X-ray sources with a pipeline fine-tuned for such crowed fields. We built a catalog with ˜15k X-ray sources within 3 degrees of SEP (˜8k within 1 degree) and identified their multiband counterparts from a few catalogs including CatWISE, NSC-DR2, S-CVZ, and GAIA-DR3. Based on multiband colors, we selected AGN from them and used the AAOmega spectrograph onboard the AAT telescope to follow them up. A large number of the X-ray sources exhibit significant variability, including a few particular targets that are possibly tidal disruption events, AGN shutting down or ignition events, or quasi-periodic oscillation cases. We study the normalized excess variance and power spectral densities of AGN with X-ray light curves, measure their optical properties, e.g., black hole mass, using optical spectra, and analyze the correlation between them.

Primary author(s) : Dr. LIU, Teng (Max Planck Institute for Extraterrestrial Physics)

Presenter(s) : Dr. LIU, Teng (Max Planck Institute for Extraterrestrial Physics)

Session Classification : Current and Future Surveys

Contribution ID : **176** Type : **Contributed talk**

AGN Variability: A ZTF perspective

Wednesday, 28 June 2023 10:30 (15)

The Zwicky Transient Factory (ZTF) has been surveying the visible sky above Dec = -30 on a 2-3 night cadence in g, r, and I for the past five years. With a 5σ detection limit of $g = 20.5$, this provides hundreds of thousands of nightly real-time public alerts as well as well-sampled light curves for over 3 billion sources. This is an unparalleled data set for both anomaly detection and population studies of many astrophysical classes but it has been particularly fruitful for supermassive black holes: both the tens of tidal disruption events found around quiescent systems but also detecting new types of phenomena in active systems. In this talk, I will review what insights ZTF is providing into the AGN Zoo with changing state quasars, ambiguous nuclear transients, and EM counterparts to stellar mass black hole mergers as well as the more general properties of the AGN population.

Primary author(s) : Dr. GRAHAM, Matthew (Caltech)

Presenter(s) : Dr. GRAHAM, Matthew (Caltech)

Session Classification : Current and Future Surveys

Contribution ID : **178** Type : **Invited talk**

Review: Continuum reverberation variability of AGN

Monday, 26 June 2023 09:45 (30)

Determining the inner geometry of AGN - i.e. the size and location of the central X-ray emitting corona relative to the accretion disc, the shape, size and structure of the disc, the location of the broad line region and its possible connection with disc winds, the location and structure of obscuring material - remains one of the main challenges of astrophysical research. Apart from M87 and SgrA*, whose very inner regions have been imaged by millimetre global VLBI, these inner structures are far too small for direct X-ray or optical imaging. We therefore use the technique of 'reverberation mapping'. Here the time lag between direct X-ray emission and lower energy (UV/optical) emission, produced by reprocessing of X-rays by the surrounding material, gives us the distance from the central X-ray source to the surrounding material. By measuring that lag in multiple wavebands, corresponding to material at a range of temperatures, we are able to map out at least the temperature structure of the surround material. We can then compare our observed structure with the structure that we expect based on theoretical models of these structures and hence determine whether the models are correct. I will review the observations that have been carried out and their implications for our understanding of the inner geometries of AGN.

Primary author(s) : Prof. MCHARDY, Ian (University of Southampton)

Presenter(s) : Prof. MCHARDY, Ian (University of Southampton)

Session Classification : X-ray/UV/optical/IR correlated variability

Contribution ID : **179** Type : **Invited talk**

Review: Spectroscopic surveys for AGN time-domaine science

Wednesday, 28 June 2023 10:00 (30)

Presenter(s) : Prof. LIRA, Paulina (Universidad de Chile)

Session Classification : Current and Future Surveys

Contribution ID : **181** Type : **Poster**

Modeling variable diffuse continuum from dusty/dustless plasma using CLOUDY

Reverberation mapping is an effective technique to understand the structure and kinematics of broad-line region (BLR) as well as the mass of the black hole. It involves measuring the time delays between the variable continuum and emission line fluxes. The expected time delay varies with the wavelength as (wavelength)^(4/3). But the observations have shown that the measured time delays are larger than the expected delays. So, it would be a good idea to estimate the contribution from different parts (including BLR) into the time-delay measurements. I'll discuss the contribution of diffuse continuum from the BLR in the time delay measurements by considering different model grids of dusty/dustless plasma using CLOUDY simulations.

Primary author(s) : PANDEY, Ashwani (Center for Theoretical Physics PAS Warsaw Poland)

Presenter(s) : PANDEY, Ashwani (Center for Theoretical Physics PAS Warsaw Poland)

Session Classification : Poster

Contribution ID : **182** Type : **Poster**

Long term monitoring of TeV Active Galaxies seen by HAWC

The High Altitude Water Cherenkov (HAWC) Observatory has been looking at the Northern sky in the TeV band since March 2015. Its long duty cycle (about 24 hours per day) allows an excellent continuous monitoring of the brightest Blazars and Radio Galaxies emitting in the gamma-ray regime. We present HAWC lights curves and TeV spectra of Mrk 421, Mrk 501 and M87 collected over 6 years. The HAWC light curves of the Blazars are complemented by quasi simultaneous X-ray monitoring by the Swift satellite in the 0.2-10 keV. The strong correlation between these two bands found in Mrk 421 is consistent with a linear dependence, which is expected if the emission mechanism is one-zone synchrotron self-Compton. The correlation between flux and spectral index for both sources, provides confirmation for the harder-when-brighter behaviour.

Primary author(s) : Dr. LONGINOTTI, Anna Lia (Universidad Nacional Autónoma de México)

Presenter(s) : Dr. LONGINOTTI, Anna Lia (Universidad Nacional Autónoma de México)

Session Classification : Poster

Contribution ID : **183** Type : **Invited talk**

Review: HST view of a multifarious landscape of winds in AGN

Friday, 30 June 2023 09:30 (30)

Winds link the supermassive black holes at the heart of active galactic nuclei (AGN) to their environment. Combined high-resolution UV and X-ray spectroscopy is a crucial tool to advance our understanding of the origin and role of these outflows in AGN. I present results from recent studies investigating the physical connection between different forms of outflows that have been found in AGN. I review the UV perspective of warm-absorber outflows, transient obscuring winds, and the ultra-fast outflows (UFOs) using spectroscopy with the Hubble Space Telescope (HST). By deciphering their variability, and mapping their ionization and kinematic structure, new insights are gained on the formation and driving of the AGN outflows.

Presenter(s) : Dr. MEHDIPOUR, Missagh (Space Telescope Science Institute)

Session Classification : Outflows

Contribution ID : **184** Type : **Poster**

Characterising the accuracy of time-scale recovery from gappy and noisy AGN light curves

The Atacama Cosmology Telescope (ACT) was a ground-based CMB experiment in the Atacama desert in Chile that observed the millimeter sky until 2022. Lightcurves have been obtained from flux measurements of point sources (AGN) in single-pass scans of ACT across the sky between 2013 and 2022. ACT currently has lightcurves for over 200 of its brightest point sources with measurements sampled on the order of a day, although these lightcurves contain gaps ranging from day to months due to details of instrument operation.

The aim of this project is to quantify how well the structure function (SF) from a "gappy" lightcurve replicates that from a full lightcurve, through the use of simulated lightcurves. This would allow us to quantify the level of uncertainty in the SF of our measured lightcurves. As different measured lightcurves have different samplings, an automated way to obtain these estimates is being developed. Here we present a preliminary study of any potential predictability in the deviations of the SF introduced by a specific sampling.

Primary author(s) : HORNECKER, Erika (University of Toronto)

Presenter(s) : HORNECKER, Erika (University of Toronto)

Session Classification : Poster