Bowen Fluorescence Flares: A New Class of Transients in Accreting SMBHs

Benny Trakhtenbrot
Tel Aviv University

with: Iair Arcavi (TAU), Lydia Makrygianni (TAU), Claudio Ricci (UDP), Hagai Netzer (TAU), Assaf Horesh (HUJI), Itai Sfaradi (HUJI), Mariusz Gromadzki (U. of Warsaw), Łukasz Wyrzykowski (U. of Warsaw), Grisha Zeltyn (TAU), Marzena Śniegowska (TAU), and many others...

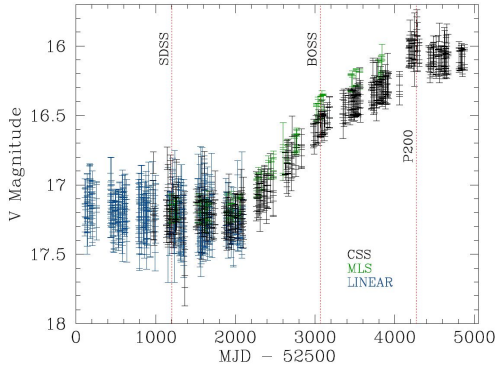
European Research Council

The Restless Nature of AGN (Δt=10 yr), Napoli, June 29th 2023

Context: *extreme AGN variability & SMBH-related transients*

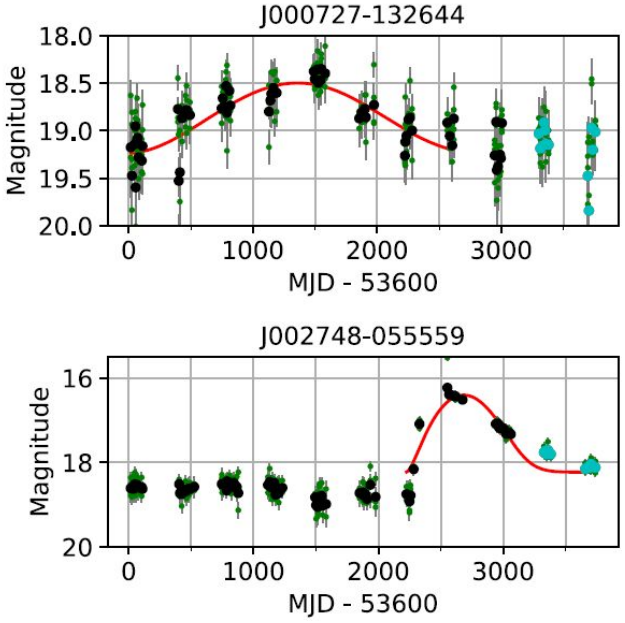
New surveys are identifying a “zoo” of new, extreme events

Changing look/state AGN



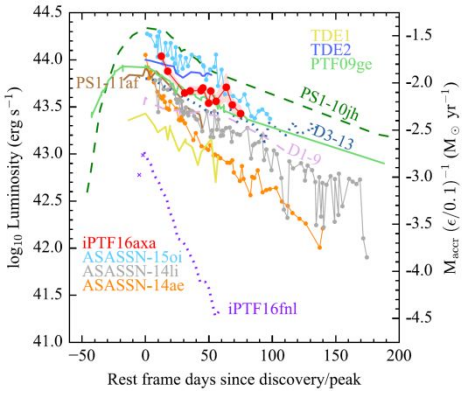
Stern+17 – fast outflow changes?

Extreme quasar variability



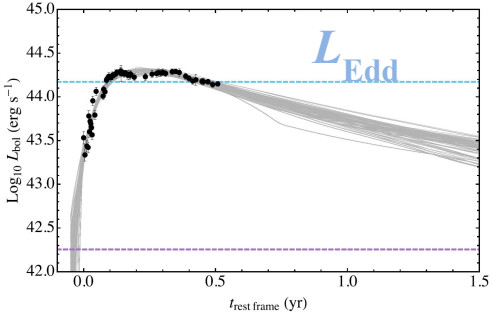
Graham+17 – Catalina (CRTS)

Tidal disruption events



Hung+17 – iPTF16axa

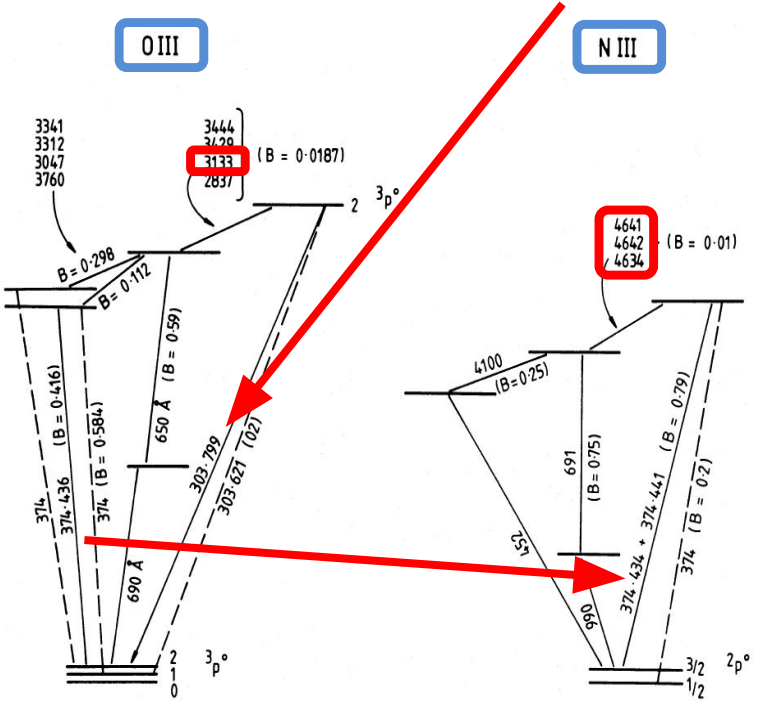
Other nuclear transients?



Blanchard+17 – PS16dtm

Context: *broad Bowen fluorescence lines in AGN*

The Lyα-like line of HeII, at **303.783Å**



Narrow Bowen fluorescence lines notably, OIII λ3133 & NIII λ4640 seen in PNe, XRBs, and (some) AGN

THE ASTROPHYSICAL JOURNAL, **299**:752–762, 1985 December 15

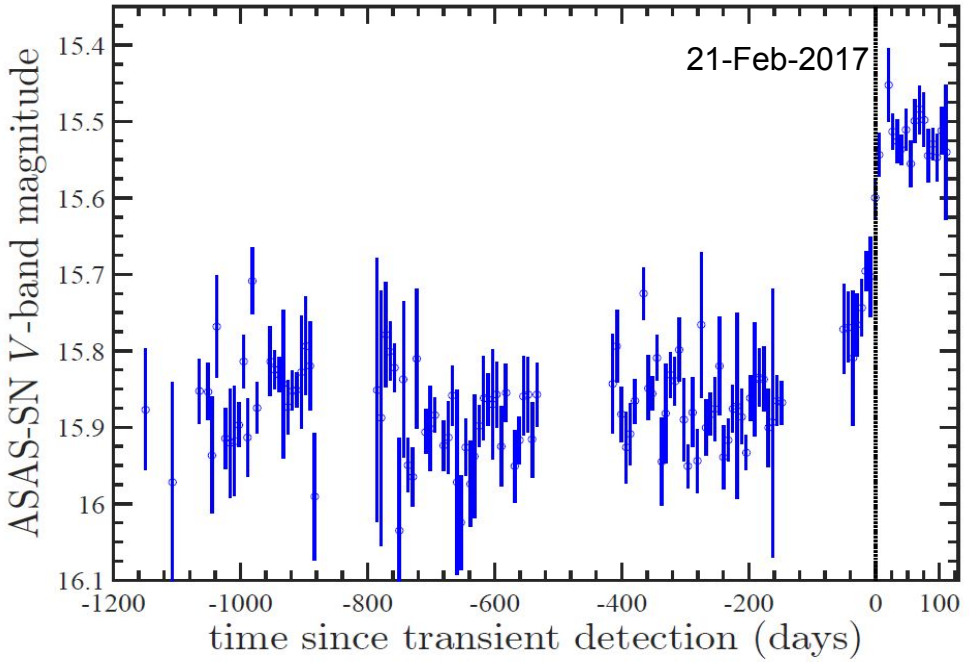
BOWEN FLUORESCENCE AND He II LINES IN ACTIVE GALAXIES AND GASEOUS NEBULAE

HAGAI NETZER[1]
Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, East Sussex
MOSHE ELITZUR
Department of Physics and Astronomy, University of Kentucky, Lexington
AND
GARY J. FERLAND
Astronomy Department, Ohio State University

LINES	a	b	c
Hβ	1	1	1
Lyα	49	23	45
Hα	10.3	5.0	9.7
Paα	1.05	0.55	1.0
He I λ5876	0.18	0.04	0.24
He II λ1640	2.96	1.56	1.5
He II λ4686	0.29	0.15	0.15
He II + O III λ304	7.8	6.5	3.5
O III + N III λ374	4.9	1.1	2.7
O III λ3133	1.38	0.38	0.74
N III λ4640	0.07	0.01	0.04

Models (1985): Broad Bowen lines *should* be seen in quasars (with strong EUV emission?)

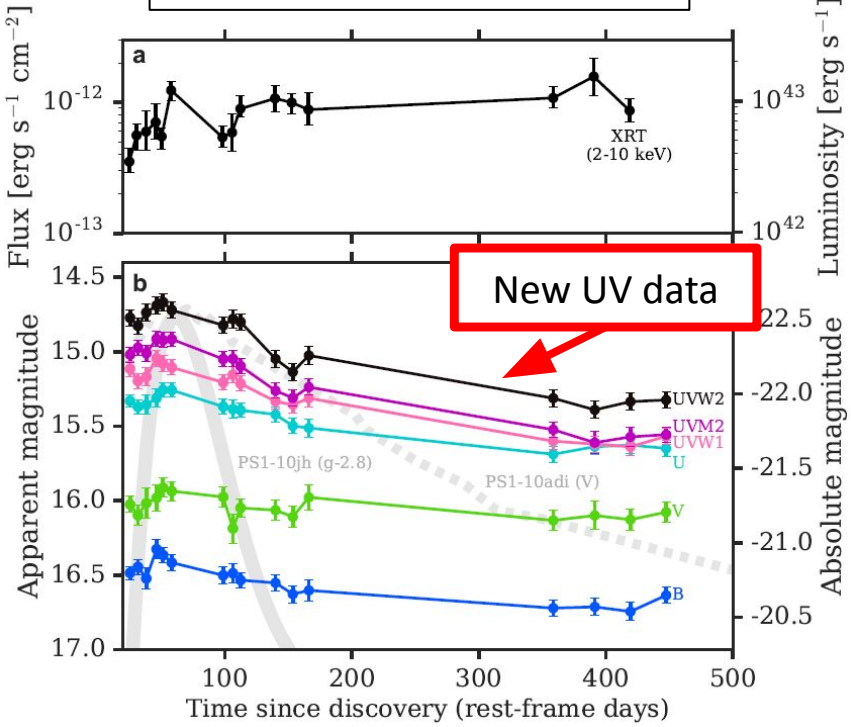
AT 2017bgt: *a UV/opt.-bright SMBH flare lasting >1 year?*



sharp rise in optical/UV, then plateau

- **NUV increased by x75** (~10^{45} erg/s)
- X-ray increased by x2-3 (~10^{43} erg/s)
- **UV-brighter than typical AGN, by x50**

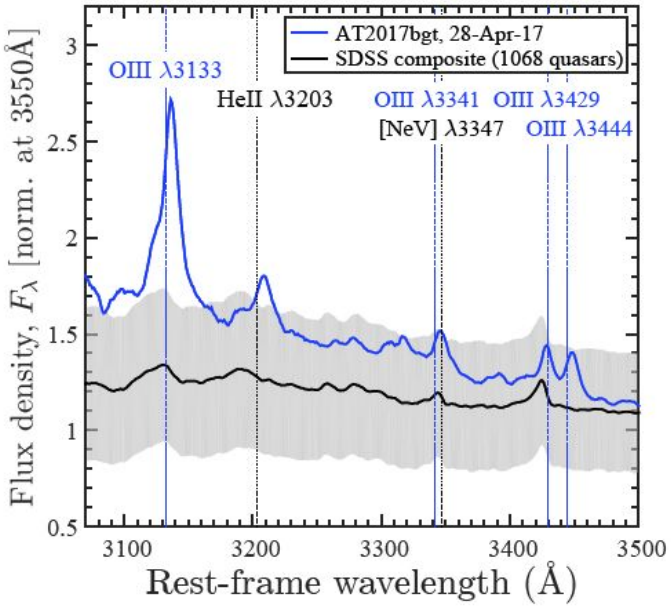
BT+19 (Nat. Astro., 3, 242)

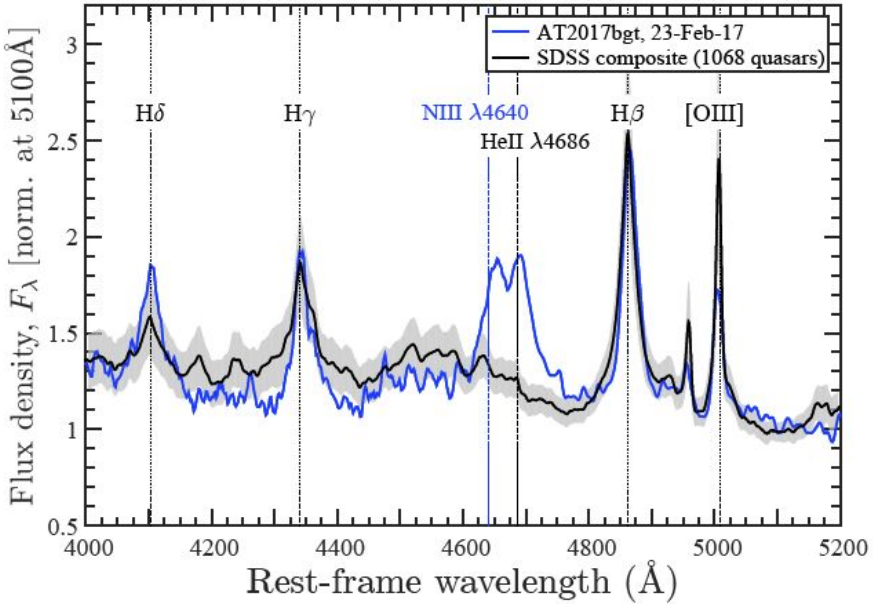


New UV data

archival UV

AT 2017bgt: *peculiar optical emission lines*

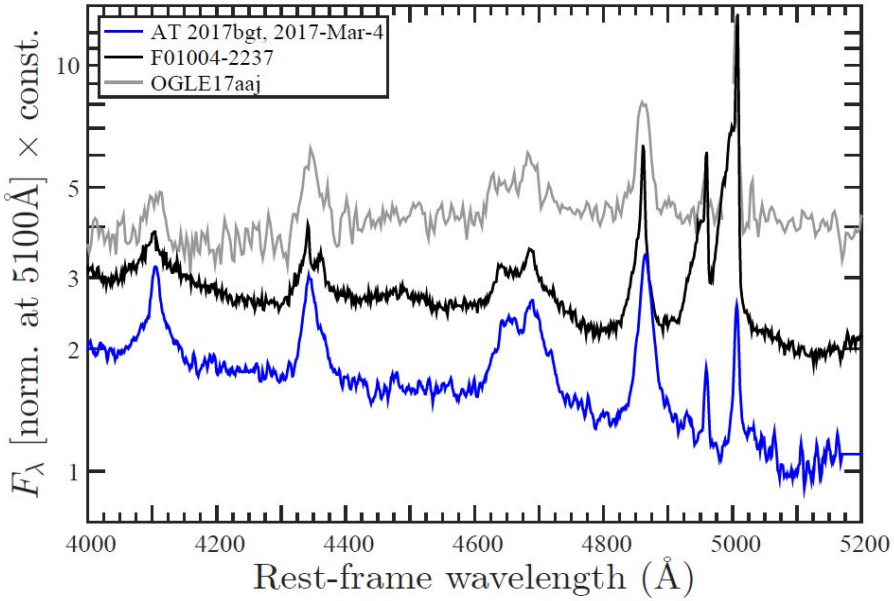




- A combination of persistent spectral features
  - AGN-like broad Balmer lines (~2000 km/s)
  - **Broad Bowen Fluorescence lines - first robust identification!**

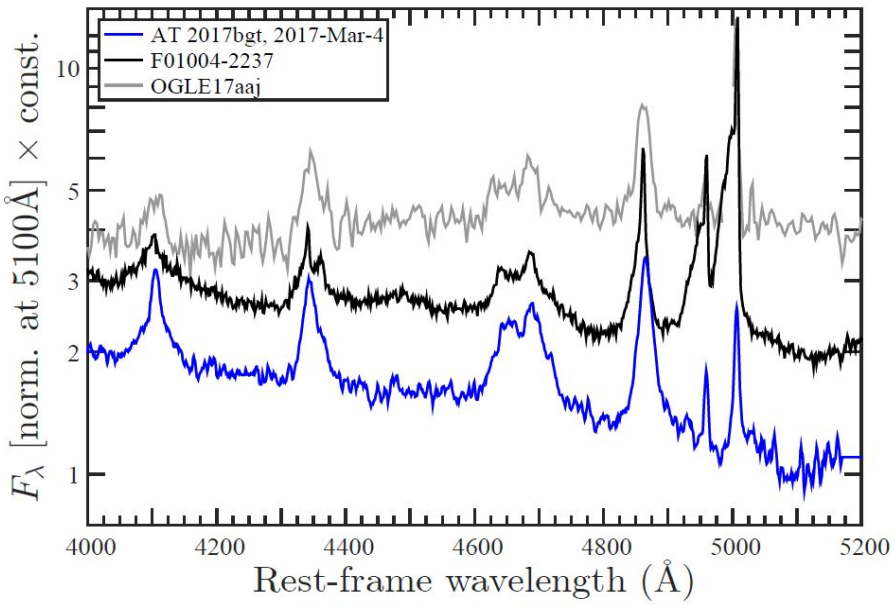
BT+19 (Nat. Astro., 3, 242)

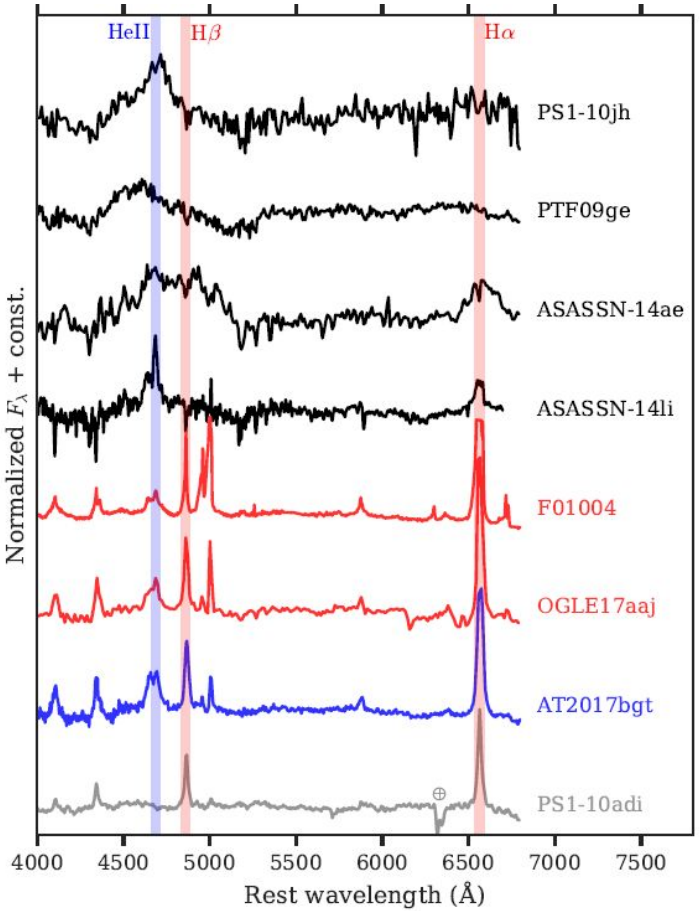
Bowen Fluorescence Flares: *a new class of flares from SMBHs*



- A combination of persistent spectral features
  - AGN-like broad Balmer lines (~2000 km/s)
  - Broad Bowen Fluorescence lines
- **At least 4 other, similar events** (Tadhunter+17, Gromadzki+19, Makrygianni+23, ...)

Bowen Fluorescence Flares: *a new class of flares from SMBHs*

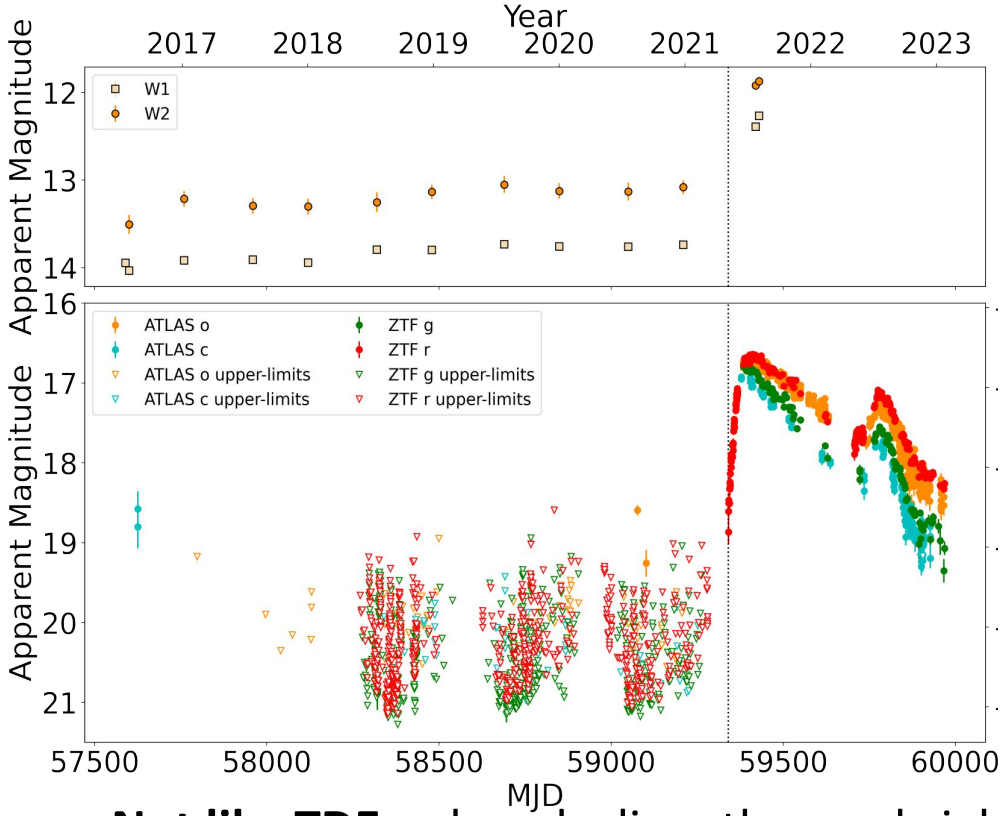


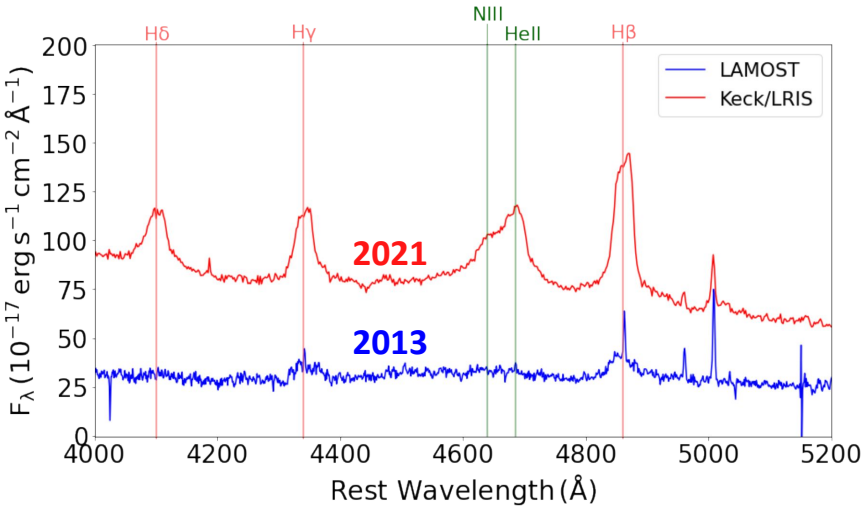


- A combination of persistent spectral features
  - AGN-like broad Balmer lines (~2000 km/s)
  - Broad Bowen Fluorescence lines
- At least 4 other, similar events
- **Not like TDEs**, despite "broad HeII λ4686 line"

AT 2021loi: *our latest Bowen Flare, found in a known quasar*

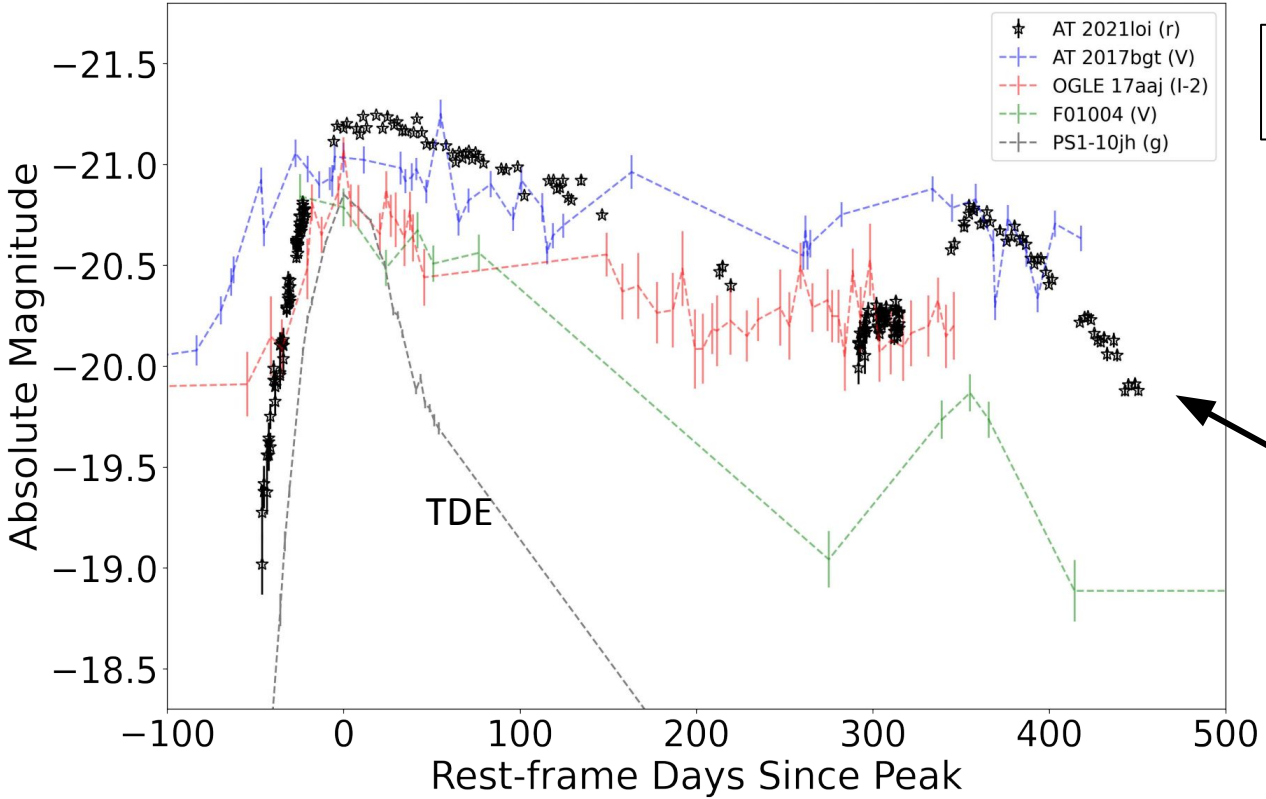
Makrygianni, BT, + 23
(arXiv:2305.01694)





- **Not like TDEs:** slow decline, then re-brightening & 2nd peak
- Pre-existing Broad Line Region = dense, ionized, optically-thick (virialized?) gas

AT 2021loi: *our latest Bowen Flare, found in a known quasar*



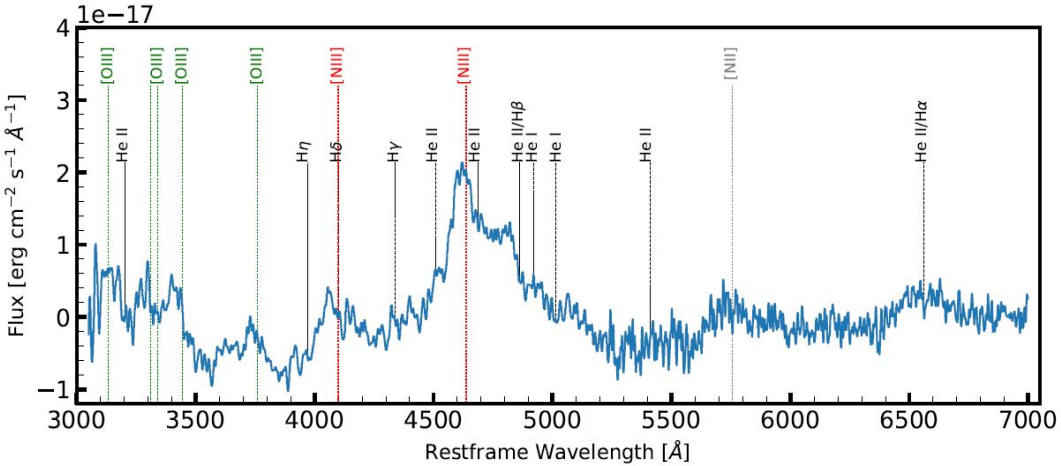
Makrygianni, BT, + 23 (arXiv:2305.01694)

AT 2021loi: another event, in a known quasar

- Not like TDEs: slow decline, then **re-brightening / 2nd peak**
- Recurring tidal interactions? EMRIs? circumbinary disks?!

Not Alone: *Bowen fluorescence in SMBH flares & TDEs?*

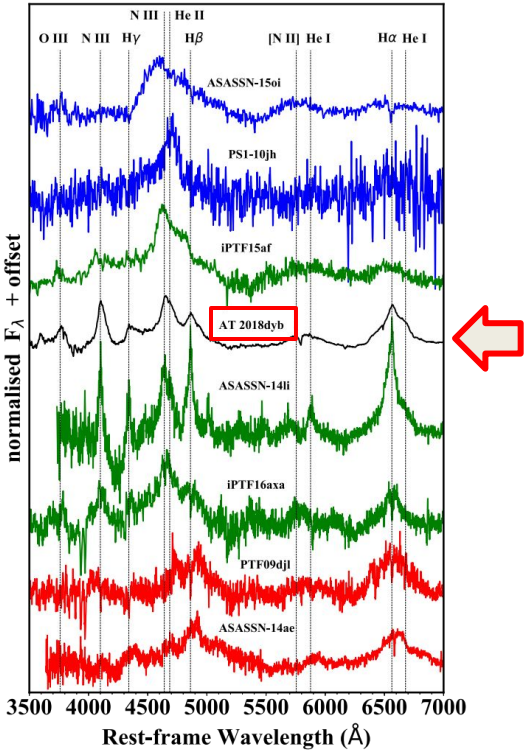
iPTF15af - a TDE with fast outflows (?)
Blagorodnova+19



- Some clear TDE signatures: high He/Hβ
- But also: Bowen lines from OIII and NIII cascades

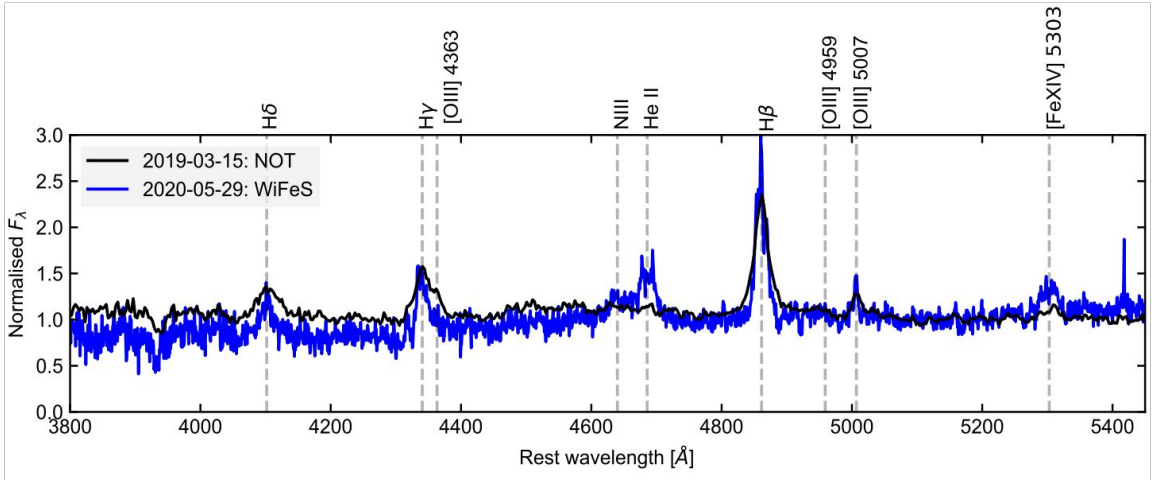
Are broad Bowen lines common in "flaring" SMBHs?
produced only in transient, UV-bright accretion events?

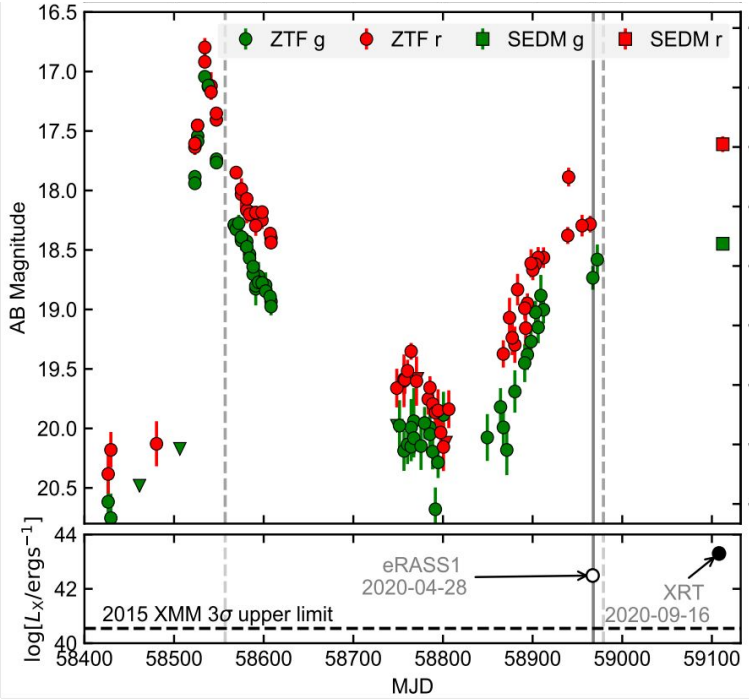
AT 2018dyb - a TDE (?)
Leloudas+19



Not Alone: *Bowen fluorescence in other SMBH flares?*

AT 2019avd - a peculiar nuclear transient (Malyali+21)

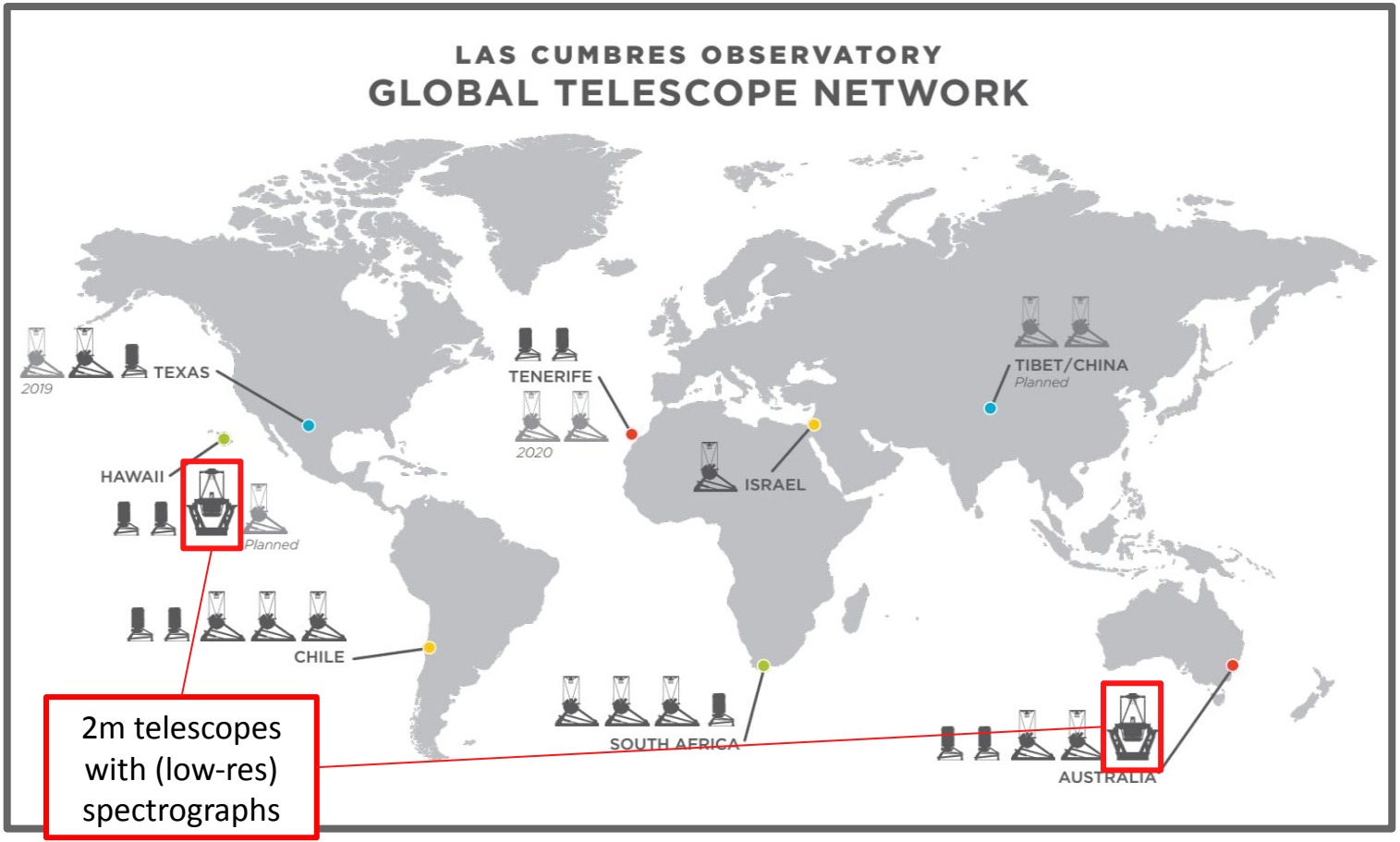




- Strong coronal & varying Bowen emission lines
- But: peculiar, double-peaked light-curve…

Are broad Bowen lines common in "flaring" SMBHs?
produced <u>only</u> in transient, UV-bright accretion events?

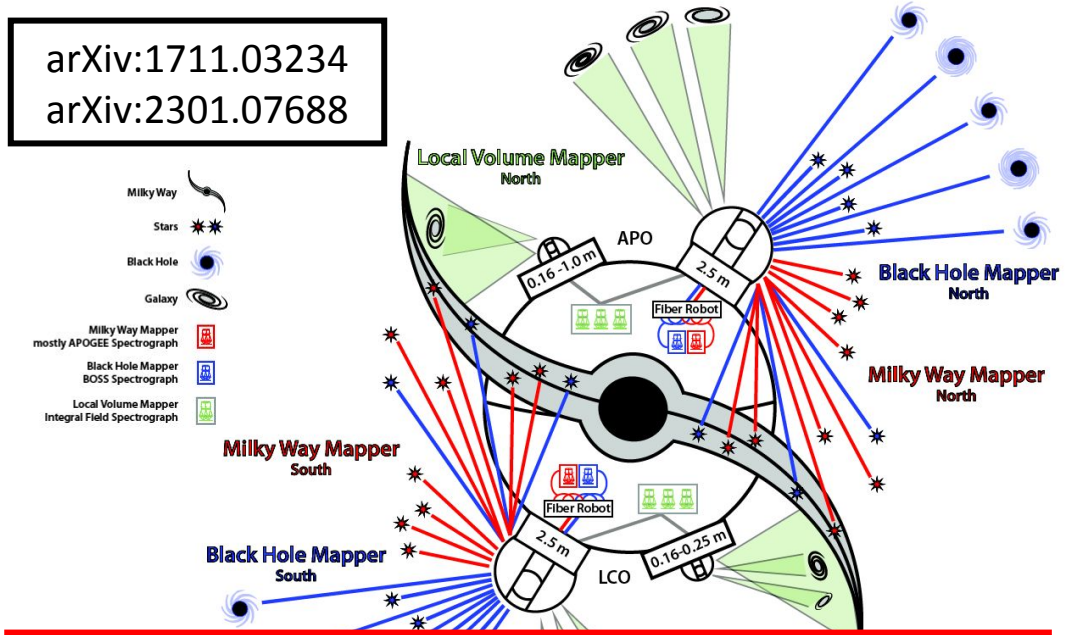
Chasing Transients: *responsive, robotic spectroscopy*



SDSS-V: *an all-sky, multi-epoch spectroscopic survey*

- Galactic & extra-galactic science
- US & Chile, legacy+new hardware
- Taking data for over a year
- *Statistics of spec. transients!*

arXiv:1711.03234
arXiv:2301.07688



SDSS-V Black Hole Mapper Targeting				
Science Goals	**Primary Selection**	**Density [deg^{-2}]**	**N$_{targets}$**	**N$_{epochs}$**
Reverberation mapping, BH masses	Optical QSOs, $i < 20$	30–50	1,500	174
BH accretion and outflow astrophysics, changing look quasars	Optical QSOs, $i < 19$	10	25,000	3–13
eROSITA follow-up, AGN, X-ray binaries, galaxy clusters	$f_{X-ray} \geq 2.5 \times 10^{-14}$ erg s^{-1} cm^{-2}, $i < 21.5$	20–50	400,000	1–3

Summary

1. New surveys are identifying extreme events related to SMBH accretion

1. **A new class of transients from accreting SMBHs**:
   - AGN with sharp UV-optical rise, year-long light curves
   - Strong, persistent broad Bowen lines
   - Probes of extreme-UV flares in the inner disk?
   - Linked to TDEs? maybe TDEs-in-AGN? recurring tidal events?

2. **Soon: a flood of (other) extreme events**
   - Can probe super-Eddington accretion, lower-mass BHs, and more…
   - Spectroscopic and multi-λ follow-up is key
   - *Diagnostics and models needed!*