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

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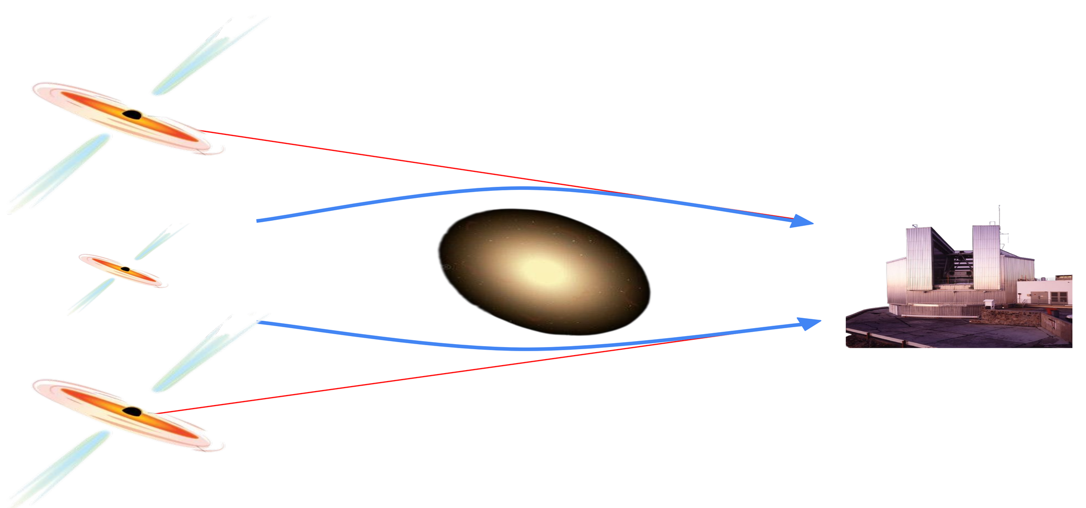
Lensed quasars

The presence of an intervening massive galaxy can bend the light of a distant quasar that is along the same line of sight as the galaxy, producing multiple projected images of the quasar. The so-called strong gravitationally lensed quasars are crucial to access key aspects of galaxy evolution such as the baryonic and dark matter distributions of the lens (Bate et al. 2011; Oguri et al. 2014), host-galaxy properties of the lensed quasar (e.g., Peng et al. 2006), or details regarding the structure and accretion process in the quasar (Hutsemékers et al. 2010; Hutsemékers & Sluse 2021; Paic et al. 2022). Lensed quasars are also a powerful tool to measure the Hubble constant, H_0, with high precision. The value of H_0 determines the present-day expansion rate of the universe and the determination of its precise value presents a challenge for cosmological models.



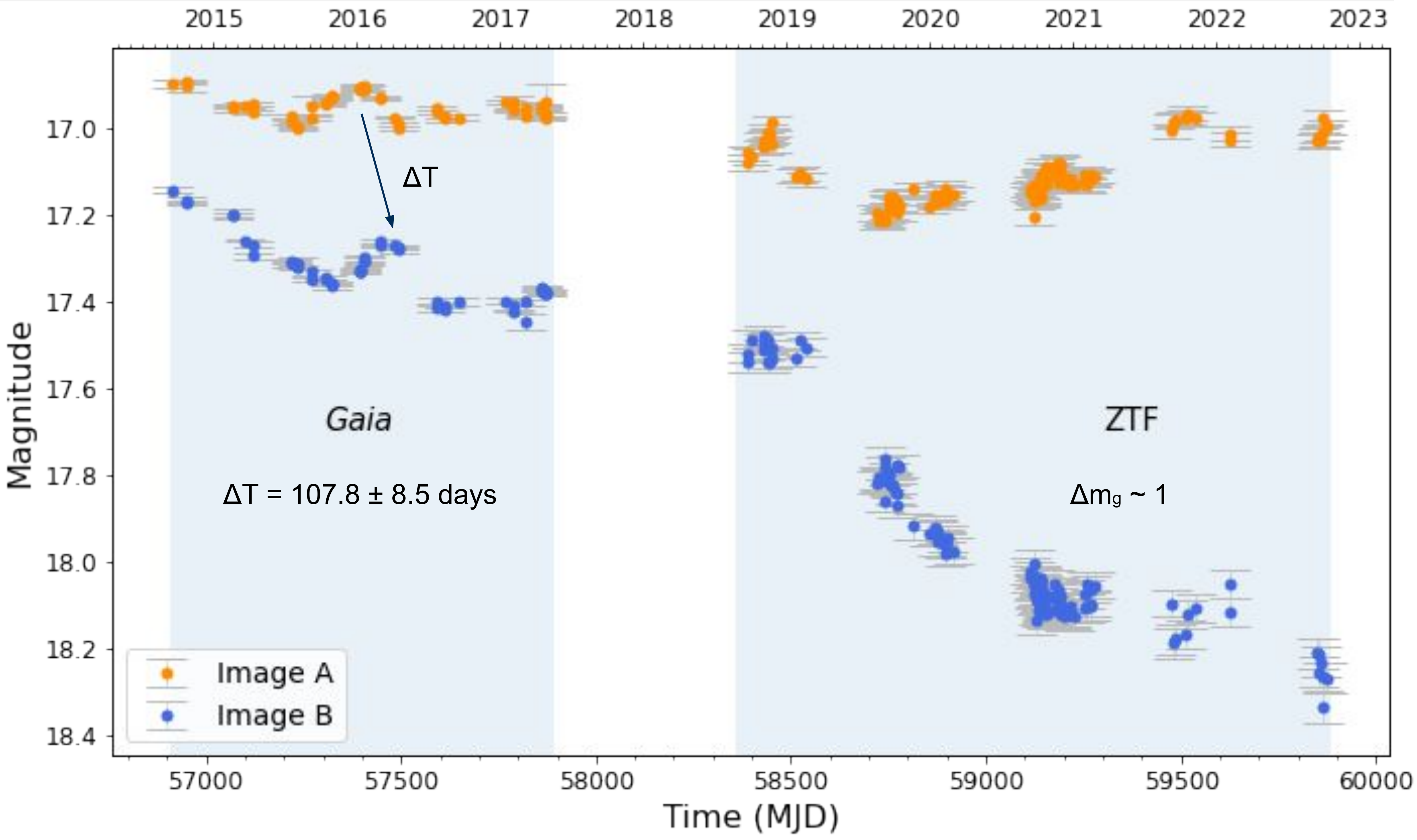
Schematic cartoon of the strong gravitational lensing process.

Time delay cosmography

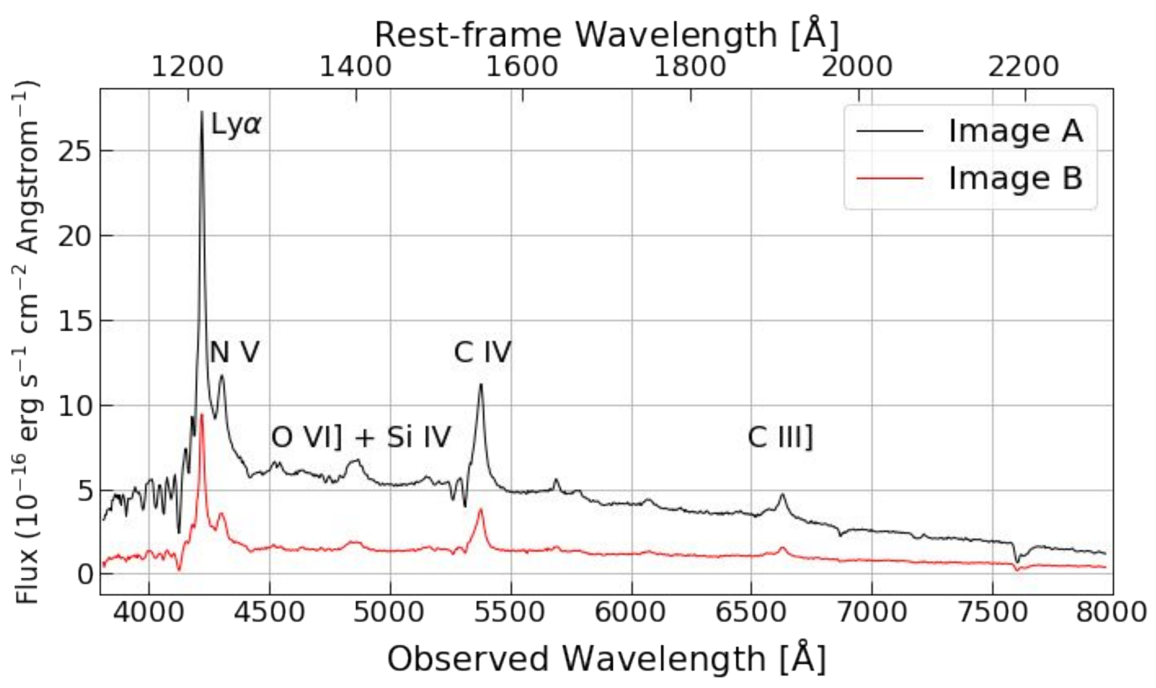
Time-delay cosmography makes use of the time lag between the lensed images of the quasar and the mass distribution of the lens to independently estimate H_0 with high precision (Refsdal 1966; Bonvin et al. 2016; Wong et al. 2017; Shajib et al. 2020; Wong et al. 2020). Since the light rays of the quasar take different paths through the lensing galaxy and its potential well, photons that were emitted at the same epoch will arrive at different times to the observer. This time delay is then associated to a cosmic distance that will depend on H_0.

eRASS1 J050129.5-073309

eRASS1 J050129.5-073309 is a new, recently discovered, bright doubly lensed quasar at redshift z = 2.47 (Tubín-Arenas et al. 2023). It was selected from the first all-sky survey of the extended ROentgen Survey with an Imaging Telescope Array (eROSITA, Merloni et al. 2012; Predehl et al. 2021) and the Gaia EDR3 catalog (Lindegren et al. 2021), and it was spectroscopically confirmed via ESO NTT/EFOSC2 observations.

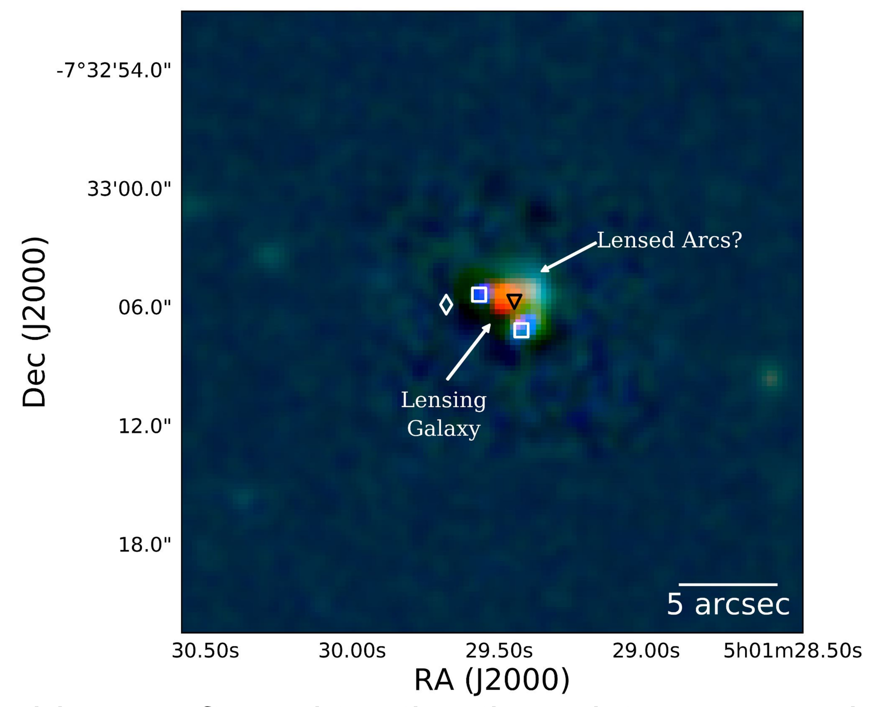


Gaia DR3 and ZTF g-band light curves for eRASS1 J050129.5-073309. The orange and blue circles correspond to image A and image B, respectively. The Gaia data cover the epoch from September 2014 to April 2017 and the ZTF data the epoch from October 2018 to August 2022. The light curve show, especially in the Gaia data, a clear time delay measurement of ΔT = 107.8 ± 8.5 days. The ZTF data show clear signatures of microlensing where the quasar from image B decreases its flux by almost one magnitude.



ESO NTT/EFOSC2 optical spectra of the two components of the lensed quasar eRASS1 J050129.5-073309. The quasar has a redshift of z = 2.47.

The two lensed images are separated by 2.7″ and their average *Gaia* g-band magnitudes are 16.9 and 17.3, respectively. Legacy Survey DR10 (Dey et al. 2019) imaging reveal the tentative position of lensing galaxy and the lensed image of the quasar host galaxy after subtracting the quasar images.



Residual image after subtracting the point source model of the quasar images. The residuals evidence the lensing galaxy and likely the lensed arcs of the quasar host galaxy.

Archival optical light curves show evidence of a time delay in the variability, with the fainter component lagging the brighter by 107.8 ± 8.5 days (Tubín-Arenas et al. 2023). The fainter image has also decreased its brightness by about 1 magnitude since 2019, probably caused by microlensing. Given the large image separation and the brightness of the quasar images, high-cadence photometric observations can be obtained with small, ground-based telescopes in order to obtain a more precise value of the variability time lag. This newly discovered lens is a *highly suitable* candidate for time-delay cosmography studies thanks to its brightness, separation, and the magnitude of the observed time delay.

References: Bate, N. F., et al. (2011), ApJ, 731, 71 - Bonvin, V., et al. (2017), MNRAS, 465, 4914 - Dey, A., et al. (2019), AJ, 157, 168 - Hutsemékers, D., et al. (2010), A&A, 519, A103 - Hutsemékers, D. & D. Sluse (2021), A&A, 654, A155 - Lindegren, L., et al. (2021), A&A, 649, A2 - Merloni, A., et al. (2012), arXiv, arXiv:1209.3114 - Oguri, M., C. E. Rusu, & E. E. Falco (2014), MNRAS, 439, 2494 - Paic, E., et al. (2022), A&A, 659, A21 - Peng, C. Y., et al. (2006), ApJ, 649, 616 - Predehl, P., et al. (2021), A&A, 647, A1 - Refsdal, S. (1966), MNRAS, 132, 101 - Shajib, A. J., et al. (2020), MNRAS, 494, 6072 - **Tubín-Arenas, D., et al. (2023), A&A, 672, L9** - Wong, K. C., et al. (2017), MNRAS, 465, 4895 - Wong, K. C., et al. (2020), MNRAS, 498, 1420

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