Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias, 60, 231-232, (2026)

OPEN ACCESS https://doi.org/10.22201/ia.14052059p.2026.60.193

Cosmological applications of newly discovered gravitational lensed quasars

V. Motta[1]

[1]*Instituto de Física y Astronomía, Universidad de Valparaíso, Avda. Gran Bretaña 1111, Valparaíso, Chile.*

Keywords: *gravitational lensing: micro, gravitational lensing: strong*

Corresponding author: veronica.motta@uv.cl

"XVII LARIM", Montevideo, Uruguay, November 27 - December 1, 2023.Volume Editors: Gonzalo Tancredi, Cecilia Mateu & Juan José Downes

Strong gravitational lensing is a useful tech- nique for examining astrophysical issues such as the general content and kinematics of the Universe. As variable sources, AGNs en- able measurements of the time delays be- tween images, which can be used to estimate absolute distances (i.e. an alternative tech- nique to constrain the Hubble constant). We present the results of an extended campaign of the Time Delay Cosmography collaboration to find new lensed quasars (brightest kind of AGNs), to produce reliable mass models and time delays.

The standard model of our universe (ΛCDM) depends on cosmological parameters associated to its components (such as dark energy, dark matter) and its expansion rate (associated to the Hubble constant, H_0). In recent years, the improvement in precision shows a discrepancy between the estimation of H_0 with data from the early and late universe (Di Valentino et al., 2021). This could be due to experimental (unknown) errors, or it could mean the need for an alternative model to ΛCDM (Efstathiou, 2021).

Strong gravitational lens provides an alternative technique to measure H_0. The gravitational lens phenomenon is produced when the light from a background quasar (source) is deviated by the gravitational potential of a foreground galaxy (lens), producing several images of the source (Schneider et al., 1992). Since the photons travel through different paths, they will reach the lens at separate times. The time lag between images (time delay, Δt) is inversely proportional to H_0:

$$\Delta t = \frac{1+z_L}{c}\frac{D_L D_S}{D_{LS}} F\left(\frac{1}{2}|\vec{\theta}-\vec{\beta}|^2 - \psi(\vec{\theta})\right) \tag{1}$$

where z_L is the redshift of the lens, D represents the observer-source (D_S), observer-lens (D_L), lens-source distances (D_{LS}), and F is a function of the positions of the images ($\vec{\theta}$), and source ($\vec{\beta}$), and the gravitational potential ($\psi(\vec{\theta})$) of the lens. The angular diameter distance depends on H_0 and the selected model for the Universe (ΛCDM in this case).

A high precision measurement of H_0 requires accurate lens models and time delays (Birrer et al., 2020). Quadruply lensed quasars are preferred to doubles because they provide better constraints (4 image positions instead of 2, sometimes arcs) and 3 time delays per system (instead of 1). However, they are a rare event. The Time Delay Cosmography (TDCosmo[1]) has double the number of quads by discovering 30 new systems (Schmidt et al., 2023).

Accurate gravitational lens models requires high-resolution imaging in several bands (preferably from space), kinematic information for the lens to break the mass-sheet degeneracy problem (Falco et al., 1985) and to account for any perturbation from neighbor galaxies in the line-of-sight. Precise time delay measurements requires high precision photometry and high cadence in telescopes able to separate the images. Finally, using blind analysis, a combination of 6 known lensed quasars provides $H_0 = 73.3^{+1.7}_{-1.8}\mathrm{kms}^{-1}Mpc^{-1}$ (Wong et al. 2020), in agreement with other estimations from the late Universe.

To summarize, gravitationally lensed quasars is able to provide a high precision H_0 estimation. The combination of several systems helps to increase that precision and could solve the tension in H_0 between the early and late universe.

References

Birrer, S., Shajib, A. J., Galan, A., et al. 2020, A&A, 643, A165, doi: 10.1051/0004-6361/202038861

Di Valentino, E., Mena, O., Pan, S., et al. 2021, Classical and Quantum Gravity, 38, 153001, doi: 10.1088/1361-6382/ac086d

Efstathiou, G. 2021, MNRAS, 505, 3866, doi: 10.1093/mnras/stab1588

Falco, E. E., Gorenstein, M. V., & Shapiro, I. I. 1985, ApJ, 289, L1, doi: 10.1086/184422

[1] https://obswww.unige.ch/~lemon/tdcosmo-master/index.html

Schmidt, T., Treu, T., Birrer, S., et al. 2023, MNRAS, 518, 1260, doi: 10.1093/mnras/stac2235

Schneider, P., Ehlers, J., & Falco, E. E. 1992, Gravitational Lenses, doi: 10.1007/978-3-662-03758-4

“XVII LARIM”, Montevideo, Uruguay, November 27 - December 1, 2023.Volume Editors: Gonzalo Tancredi, Cecilia Mateu & Juan José Downes