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Correction to: Redshift drift and strong gravitational lensing

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Key words: errata, addenda – gravitational lensing: strong – galaxies: clusters: general – galaxies: distances and redshifts – dark matter – cosmology: miscellaneous – cosmology: theory.

Unfortunately, my recent paper (Helbig 2023) contains a mistake. I wrote that '[b]y measuring the difference in redshift between two images, one effectively measures the time delay'. However, the difference in redshift is proportional to the time delay *and* to the Hubble constant (my equation 5), thus one cannot use the measured difference in redshift between images of a gravitational-lens system in order to measure the Hubble constant.

In practice, that that is not possible is of little disadvantage, as the Hubble constant is, despite the 'Hubble tension', known better than the mass model of a cluster lens (which, because of the longer typical time delay and hence larger redshift difference, one would use to make such a measurement, as opposed to a galaxy lens). Rather, one would use measured redshift differences and a known Hubble constant (and other cosmological parameters) in order to constrain the mass model of the cluster, as I mentioned in section 3 (ninth paragraph).

On the other hand, the redshift difference is, to first order, independent of the Hubble constant, since the redshift difference is proportional to the time delay and the Hubble constant, while the time delay itself is inversely proportional to the Hubble constant (Wang, Bolejko & Lewis 2023, see their equation 3 and the related discussion). That means that one can in principle use the redshift difference to measure the other cosmological parameters without knowledge of the Hubble constant.

The time delay is inversely proportional to the Hubble constant in the sense that, for a given set of typical observables in a gravitational-lens system (e.g. angular image positions and flux ratios, hence independent of any absolute scale), it is given by

$$\Delta t = {H_0}^{-1} T f \, , \tag{1}$$

where Δt the time delay, T the cosmological correction function (see below), and f is a dimensionless quantity constructed from observational quantities such as image separations, flux ratios, and the relative mass distribution of the lens, all such quantities assumed to be fixed (Kayser & Refsdal 1983).

$$T := \frac{H_0}{c} \frac{D_\mathrm{d} D_\mathrm{s}}{D_\mathrm{ds}} (1 + z_D) \frac{z_\mathrm{s} - z_\mathrm{d}}{z_\mathrm{d} z_\mathrm{s}} \tag{2}$$

(so defined so that $T \to 0$ for $z_\mathrm{s} \to 0$); D_d, D_ds, and D_s are the dimensionless angular-size distancees between observer and deflector (lens), deflector and source, and observer and source, respectively, being calculated from the redshifts and the cosmological parameters λ_0 and Ω_0 in units of $c{H_0}^{-1}$ (e.g. Kayser, Helbig & Schramm 1997). T is thus dimensionless and so the time delay Δt is inversely proportional to H_0. In other words, in such cases there is no absolute scale as long as only dimensionless quantities are involved; the measurement of a time delay thus sets a physical scale and is inversely proportional to the Hubble constant because the calculated angular-size distances are calculated in units of $c{H_0}^{-1}$.

All other aspects of my paper are unaffected: consistency check on standard cosmology, using an Einstein ring to correct for the change in redshift due to the moving-lens effect, effectively measuring time delays (for a given Hubble constant!) on much longer timescales and/or for non-variable sources, measuring the transverse velocity of the lens, and determing which images in a complex gravitational-lens system correspond to the same source.

DATA AVAILABILITY

There are no new data associated with this article.

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