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"Bayesian Estimates of Time Delays between Gravitationally Lensed Stochastic Light Curves and Time Delay Challenge II"

The gravitational field of a galaxy can act as a lens and deflect the light emitted by a more distant object such as a quasar. If the galaxy is a strong gravitational lens, it can produce multiple images of the same quasar in the sky. Since the light in each gravitationally lensed image traverses a different path length from the quasar to the Earth, fluctuations in the source brightness are observed in the several images at different times. The time delay between these fluctuations can be used to constrain cosmological parameters, e.g., Ho, and can be inferred from the time series of brightness data or light curves of each image. To estimate the time delay, we construct a model based on a state-space representation for irregularly observed time series generated by a latent continuous-time damped random-walk process. We account for microlensing, an additional source of independent long-term extrinsic variability, via a polynomial regression. Our Bayesian strategy adopts a Gibbs sampler. We introduce a profile likelihood of the time delay as an approximation of its marginal posterior distribution. The Bayesian and profile likelihood approaches complement each other, producing almost identical results. We demonstrate our estimation strategy and describe the second Time Delay Challenge using simulated data of a doubly-lensed quasar, and observed data from quasars J1029+2623 and Q0957+561.