Cosmology with Gravitational Lens Time Delays
Keith Bechtol

Light rays originating from a distant galaxy and passing near a foreground massive object can be deflected in a way that produces multiple source images - a visually spectacular effect known as strong gravitational lensing. The resultant images are often distorted and highly magnified. Gravitational lensing can be conceptualized as a generalization of Fermat's Principle that light rays follow paths of shortest time between two points, but including effects of curved spacetime. Importantly, each lensed image can have a distinct time delay resulting from different paths taken through the foreground gravitational potential, and the time delay differences are a sensitive probe of the current expansion rate of the Universe. Several gravitation lens systems featuring variable multiply-imaged sources for which time delay differences can be measured have already been identified. Upcoming surveys, especially the Large Synoptic Survey Telescope (LSST) with enormous sky coverage and high observing cadence, are expected to find statistically large numbers of such systems and enable new cosmological investigations.