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# Real-Time Astrometric Cosmology

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## Abstract

Ours is a dynamic universe, and most cosmological observables change slowly over time. One can compensate for the short careers of astronomers by seeking high precision, and "real-time" cosmology is now possible with precision astrometry. In an expanding universe, objects will appear to shrink as they recede, providing a geometrical distance measurement. Large-scale structures of galaxies can be observed to collapse in real time. Gravitational waves will cause distant objects to appear to move in the sky. Anisotropy or violation of the Copernican Principle will manifest as cosmic shear. The acceleration of the Sun's orbit causes distant quasars to appear to stream toward the Galactic Center, but this streaming will appear to drift over time. The motion of the Sun with respect to the Cosmic Microwave Background provides a means to measure the secular parallax (and thus distance) of galaxies in the local universe and resolve the current tension with galaxy counts. The proper rotation of galaxies can be observed (the infamous van Maanen effect), providing geometric distances. I present theoretical predictions of, and the first application of observations to, many of these phenomena and demonstrate that we can expect to measure most of these effects using future astrometric facilities.

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