PROGRESS TOWARD A TRIGONOMETRIC PARALLAX OF SGR A*

M. J. REID
Harvard-Smithsonian Center for Astrophysics
Cambridge, MA, 02138, USA

A. C. S. READHEAD & R. VERMEULEN
California Institute of Technology
Pasadena, CA, 91109, USA

AND

R. TREUHAFT
Jet Propulsion Laboratory
Pasadena, CA, 91109, USA

1. Introduction

In 1918, Harlow Shapley first noted that globular clusters were concentrated toward the constellation of Sagittarius, and hence the Sun was not near the center of the Milky Way. Since that time astronomers have expended considerable effort to determine the distance to the center of the Milky Way, because any change in the value of this distance, R_0, has a widespread impact on astronomy and astrophysics. Beginning in 1991, we have conducted observations with the VLBA designed to make possible a program to measure the distance to the Galactic Center via a trigonometric parallax. This could be accomplished with the VLBA using Sgr A* as a phase reference for one or more (weaker) compact extragalactic sources. A time series of measurements of the position of Sgr A* relative to an extragalactic source should show the effects of the annual $\approx \pm 0.12$ mas signature of the Earth's orbit around the Sun (trigonometric parallax), as well as the ≈ 6 mas yr^{-1} secular motion caused by the Sun's orbit around the Galactic Center.

Y. Sofue (ed.), The Central Regions of the Galaxy and Galaxies, 435-436.

2. Recent Progress

We have achieved the following milestones necessary for this experiment to be successful:

- Found 2 quasars (1748-291 and 1745-283) strong and compact enough at 43 GHz to serve as background position references for Sgr A*. These quasars have no discernible structure in our 1 mas beam and are within 0.7 degrees of Sgr A*.
- Established an optimum observing strategy of switching among the quasars and Sgr A* every 15 seconds. This switching is rapid enough to allow phase referencing while maintaining a 50% on-source duty cycle. Extremely rapid switching is necessary because of the low source elevations ($\approx 20^o$) and high observing frequency (43 GHz–chosen to avoid over-resolving Sgr A* which is extremely scatter broadened).
- Determined that the limiting source of systematic error is the large-scale atmospheric model. We currently have uncertainties of ≈ 1 cm in the vertical atmospheric path-length parameters, which can be shown to limit our relative astrometric accuracy to a few tenths of a mas.
- Demonstrated 0.1 and 0.3 mas relative positional accuracy in the East-West and North-South direction, respectively, based on observations made about 10 days apart. This has allowed us to measure the angular rotation rate of the Sun around the Galactic Center with about an 8% uncertainty over a time span of only 1 year.

With our current astrometric accuracy, we could determine the angular rotation of the Sun around the Galactic Center to about 1% within a few years! This would provide a direct measurement of Oort's constants, provided only that the Milky Way has a flat rotation curve. We hope to establish a new level of astrometric precision for Sgr A* with the VLBA and achieve a relative positional accuracy of 0.03 mas across 0.7 degrees on the sky. Approximately 25 epochs of observations spaced over a few years would suffice to measure the distance to the Galactic Center with a 5% uncertainty.

Finally, our observations can put stringent limits, or perhaps detect, any peculiar motion of Sgr A* (beyond that expected from our moving vantage point at the Sun). If Sgr A* is a very massive (e.g., $> 10^6\ M_\odot$) black hole at the dynamical center of the Galaxy, one would expect a peculiar motion of order 1 km s^{-1}, owing to gravitational perturbations from close encounters with massive stars in the central star cluster. However, were Sgr A* to be a lower mass system, commensurate with its modest total luminosity, it would be expected to have a significant peculiar motion.