HIGH PROPER MOTIONS IN THE VICINITY OF SGR A*

Unambiguous Evidence for a Massive Central Black Hole

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Although the notion that the Milky Way galaxy contains a supermassive central black hole has been around for more than two decades, it has been difficult to prove that one exists. The challenge is to assess the distribution of matter in the few central parsecs of the Galaxy. Assuming that gravity is the dominant force, the motion of the stars and gas in the vicinity of the putative black hole offers a robust method for accomplishing this task, by revealing the mass interior to the radius of the objects studied. Thus objects located closest to the Galactic Center provide the strongest constraints on the black hole hypothesis.

Since it is the angular resolution that dictates the minimum radius at which stars can be observed, it is crucial to attain the finest resolution possible. Turbulence in the earth's atmosphere distorts astronomical images and typically limits the angular resolution of long -exposures to ~ 1 arcsec, an order of magnitude worse than the theoretical limit for large ground-based telescopes ($\theta \sim \lambda/D$). With a distance of 8 kpc to the Galactic center (Reid 1993), these types of observations have been limited to estimating a central mass constrained only to a volume of radius greater than or equal to ~ 0.1 pc (e.g., Lacy et al. 1980, McGinn et al. 1989, Haller et al. 1996; Genzel et al. 1996). In contrast to long exposures, short exposures, although distorted, preserve high spatial resolution information which can be used to recover diffraction limited images via a number of different techniques such as the relatively simple and straight forward method of "Shift-and-Add" (Christou 1991). Eckart & Genzel (1996, 1997) applied this method to data from the ESO 3-m NTT and achieved a resolution of $0.''15$ in the first proper motion study of the central stellar cluster. This technique applied to data obtained from the W. M. Keck 10-meter telescope, the largest optical/infrared telescope in the world, provides a unique opportunity to study the Galactic center at an unprecedented resolution of $0.''05$ (Klein et

Y. Sofue (ed.), The Central Regions of the Galaxy and Galaxies, 433-434.

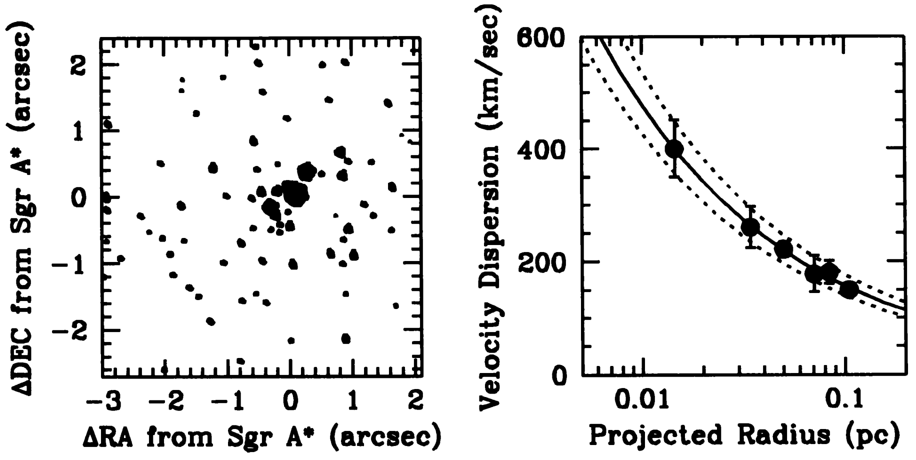

Figure 1. *Left:* The positions of the 80 stars that were unambiguously detected in all three years are displayed with pointsizes scaled to the stars' velocities. A clear increase in the velocities is visible at the field center, where stars reach velocities of 1,700 km/sec! *Right:* The projected stellar velocity dispersion as a function of projected distance from Sgr A* is consistent with Keplerian motion and implies an enclosed mass of $2.7 \times 10^6 M_\odot$.

al. 1996).

Based on diffraction-limited images obtained from 1995 to 1997, we derive the initial results for our proper motion study of the Galaxy's central stellar cluster. Within our 5"x5" field of view, the motion of 80 stars are tracked over two years (see Figure). With two dimensional velocities as high as 1,700 km/sec, these stars imply a central mass of $2.7 \pm 0.2 \times 10^6 M_\odot$ interior to a radius of ~ 0.01 pc, or densities in excess of $10^{12} M_\odot/pc^3$. This exceeds volume averaged mass densities inferred for any other galaxy and leads us to conclude that our Galaxy harbors a massive central black hole.

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