

GSMT Studies of Massive Black Hole SgrA* at the Galactic Center

The nearest example of a supermassive black hole is SgrA*, being closer by at least a factor of 300 than the next candidate. It is the best studied example of the genre. At radio wavelengths, it is a bright continuum source, which remains unresolved even at millimeter wavelengths. With VLBI techniques, there is only the slightest hint that structures may be detectable at about 70 Schwarzschild radii. At optical and near-infrared wavelengths, SgrA* is not detected. However, there are a number of stellar objects which have been seen to be in orbit around SgrA*, with proper motion velocities exceeding 5000 km/s. Studies over the past ten years have now demonstrated that some of these stellar orbits are bound. In particular, one object known as S2, is in a tight elliptical Keplerian orbit, with a semimajor axis of 5.5 light days, an orbital period of 15.2 years, and the nearest approach to SgrA* of 17 light hours (124 AU). The orbital motions are direct probes of the gravitational field. The deduced enclosed mass is 3.7 million solar masses. The extremely close approach distance to SgrA* eliminates the other possible explanations for this enigmatic source, such as a dense cluster of dark stellar matter or degenerate fermions. The observed data constitute the best observational evidence for a supermassive black hole.

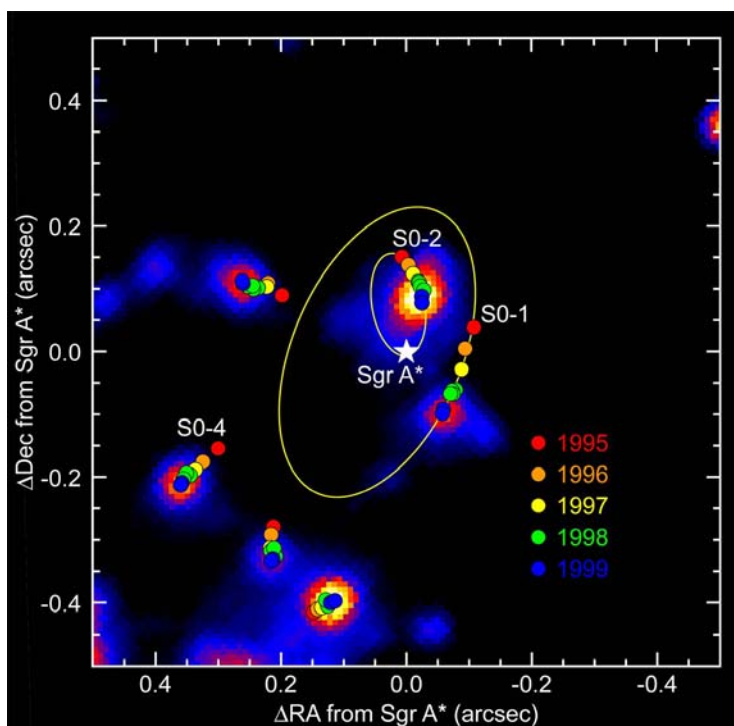


Figure 1. The proper motions of a number of stars in the immediate vicinity of SgrA*.

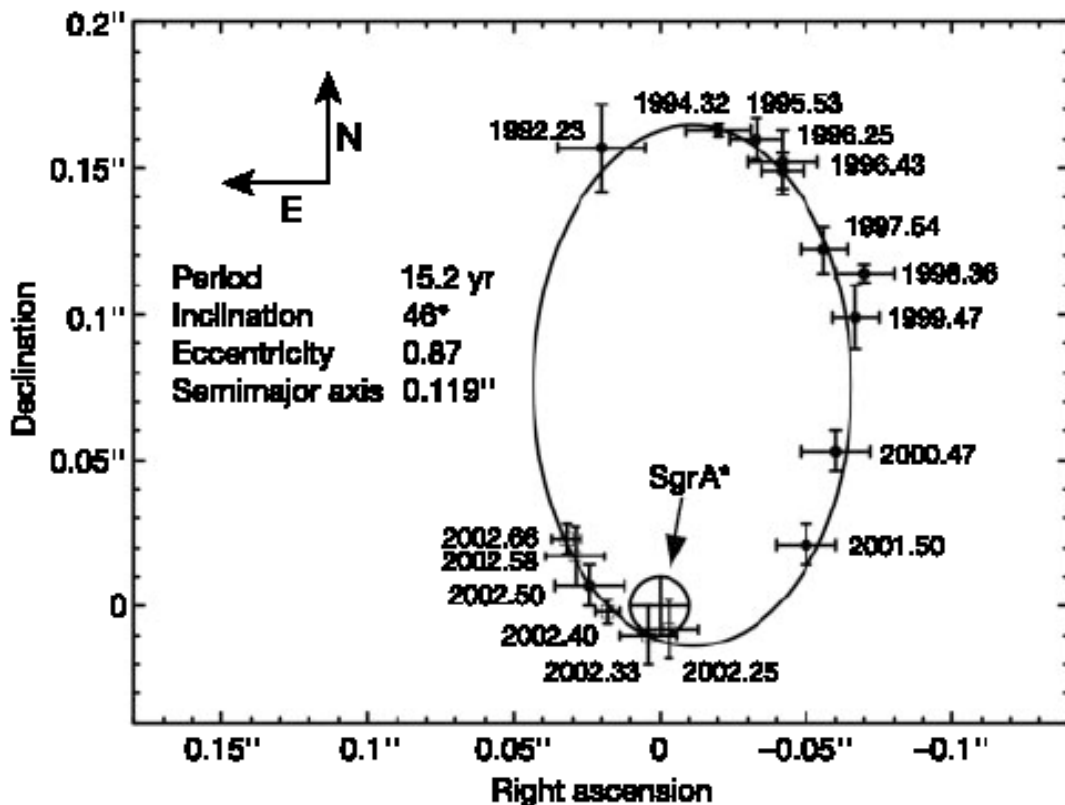


Figure 2. The measurements of the orbit of SO-2 around SgrA* over the period of 1994 to 2002 (Schodel et al. 2002). Note the extremely fast motions of SO-2 as it swings past SgrA* over a period of only 5 months. This is due to the extremely close approach to the center of the gravitational potential well.

The pericentre distance is only 2100 Schwarzschild radii, and only 70 times the tidal radius (16 light minutes). This suggests that with greater sensitivity and greater angular resolutions, there exist the possibility of detecting other stellar objects which might approach even closer to the central point mass. The importance of these proper motion studies is that the stellar objects are like test particles which sample the gravitational field very close in to a massive black holes. We have the sensitivity to follow these test particles, and furthermore we know there are more test particles to be detected.

The GSMT can provide much better sensitivity, and much higher angular resolution, assuming that adaptive optics will work successfully. This will enable detection of fainter sources, better constraints on orbital parameters on a shorter time line, probe deeper hopefully into the potential well, detect acceleration effects, detect possibly tidal effects, detect possibly relativistic motions at 100 Schwarzschild radii. This is an unique opportunity to learn as much as we can about a supermassive black hole.