APR12-2011-000082

Abstract for an Invited Paper
for the APR12 Meeting of
the American Physical Society

Evidence for a Super-massive Black Hole at the Center of the Milky Way

MARK REID, Harvard-Smithsonian Center for Astrophysics

While the concept of a black hole formed by the explosive collapse of a dying star is astounding, the possibility that matter from billions of stars can condense into a single super-massive black hole (SMBH) is even more fantastic. Yet astronomers are now confident that they exist at the centers of most galaxies and hold more than 0.01% of the baryonic mass of the Universe. Early evidence for SMBHs came from "radio galaxies" with two lobes symmetrically placed about the parent galaxy. These lobes are immense and *minimum* energy estimates require the total conversion of 10^7 stars to energy! The source of energy was traced to galaxy's center and observed to vary on time scales < 1 year. Since nuclear reactions convert less than 1% of mass to energy, this would require channeling $> 10^9$ stars through a region smaller than that between the Sun and the nearest star. A very compact radio source was discovered toward the center of the Milky Way and named Sgr A*, leading to speculation that it might be a SMBH. Infrared observations of stars on elliptical orbits give clear evidence of an unseen gravitational source of 4×10^6 solar masses. One star has been seen moving at 5000 km/s in its 16 year eccentric orbit. Sgr A* has been located at the position of the gravitational focus of the stellar orbits. However, in contrast to the rapidly moving stars, Sgr A* is motionless (< 1 km/s), requiring the source to be extremely massive. For comparison, gravitational "Brownian motion" of a SMBH at the center of a dense stellar cluster would be comparable to the measured limits. Recent radio interferometric observations show that the radio emission from Sgr A* comes from a region comparable in size to the Schwarzschild radius ($2GM/c^2$) of 0.1 AU (1.5×10^7 km)! Placing any known concentration of 4×10^6 solar masses within this tiny volume would rapidly condense to a black hole.