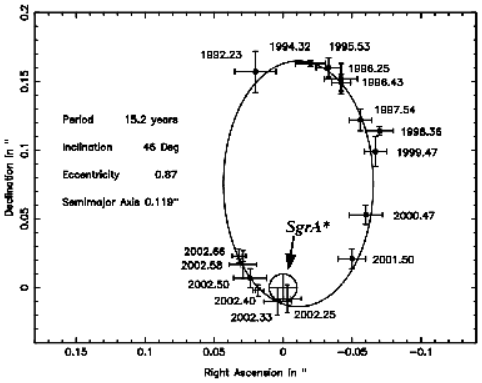
Black Holes…..V



At the center of our Milky Way Galaxy lies a black hole, called Sagittarius A*, with over 2.6 million times the mass of the Sun. Once a controversial claim, this astounding conclusion is now virtually inescapable and based on observations of stars orbiting very near the galactic center.

Astronomers patiently followed the orbit of a particular star, designated S2. Their results convincingly show that S2 is moving under the influence of the enormous gravity of an unseen object which must be extremely compact, and contain huge amounts of matter -- a supermassive black hole. The drawing shows the orbit shape.

The Chandra image above shows the x-ray light from a region of space a few light years across. The black hole is invisible, but is near the center of this image. The gas near the center produces x-ray light as it is heated. Many of the 'stars' in the field probably have much smaller black holes near them that are producing the x-ray light from the gas they are consuming.

Chandra image: http://chandra.harvard.edu/photo/2003/0203long/

Problem 1 - Kepler's Third Law can be used to determine the mass of a body by measuring the orbital period, T, and orbit radius, R, of a satellite. If R is given in units of the Astronomical Unit (AU) and T is in years, the relationship becomes $R^3 / T^2 = M$, where M is the mass of the body in multiples of the sun's mass. In these units, for Earth, R = 1.0 AU, and T = 1 year, so M = 1.0 solar masses. In 2006, the Hubble Space Telescope, found that the star Polaris has a companion, Polaris Ab, whose distance from Polaris is 18.5 AU and has a period of 30 years. What is the mass of Polaris?

Problem 2 - The star S2 orbits the supermassive black hole Sagittarius A*. Its period is 15.2 years, and its orbit distance is about 840 AU. What is the estimated mass of the black hole at the center of the Milky Way?

Answer Key:

Problem 1 - Kepler's Third Law can be used to determine the mass of a body by measuring the orbital period, T, and orbit radius, R, of a satellite. If R is given in units of the Astronomical Unit (AU) and T is in years, the relationship becomes $R^3 / T^2 = M$, where M is the mass of the body in multiples of the sun's mass. In these units, for Earth, R = 1.0 AU, and T = 1 year, so M = 1.0 solar masses. In 2006, the Hubble Space Telescope, found that the star Polaris has a companion, Polaris Ab, whose distance from Polaris is 18.5 AU and has a period of 30 years. What is the mass of Polaris?

Answer: $M = (18.5)^3 / (30)^2 = 7.0$ solar masses.

Problem 2 - The star S2 orbits the supermassive black hole Sagittarius A*. Its period is 15.2 years, and its orbit distance is about 840 AU. What is the estimated mass of the black hole at the center of the Milky Way?

Answer: $M = (840)^3 / (15.2)^2 = 2.6 \times 10^6$ solar masses.

The infrared image below shows the central few light years of the Milky Way. The box contains the location of the supermassive black hole and Sagittarius A*. (Courtesy ESA - NAOS)