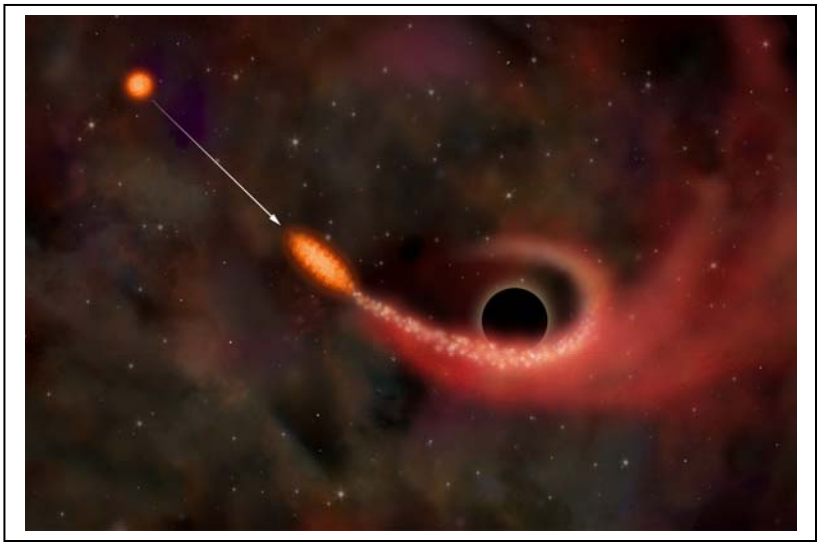
Black Holes....IV



Thanks to two orbiting X-ray observatories, astronomers have the first strong evidence of a supermassive black hole ripping apart a star and consuming a portion of it. The event, captured by NASA's Chandra and ESA's XMM-Newton X-ray Observatories, had long been predicted by theory, but never confirmed ... until now. Giant black holes in just the right mass range would pull on the front of a closely passing star much more strongly than on the back. Such a strong tidal force would stretch out a star and likely cause some of the star's gasses to fall into the black hole. The infalling gas has been predicted to emit just the same blast of X-rays that have recently been seen in the center of galaxy RX J1242-11 located 700 million light years from the Milky Way, in the constellation Virgo. (News Report at: http://science.msfc.nasa.gov/headlines/y2004/18feb_mayhem.htm, see also NASA report at http://chandra.harvard.edu/photo/2004/rxj1242/

Problem 1 - The Schwarschild Radius of a black hole is given by the formula R = 2.83 M, where R is the radius in kilometers, and M is that mass of the black hole in units of the sun's mass. A supermassive black hole can have a mass of 100 million times the sun. What is its Schwarschild radius in: A) kilometers B) Multiples of the Earth orbit radius called an Astronomical Unit (1 AU = 147 million kilometers). C) Compared to the orbit of Mars (1.5 U)

Problem 2 - Black holes are one of the most efficient phenomena in converting matter into energy. As matter falls inward in an orbiting disk of gas, friction heats the gas up, and the energy released can be as much as 7% of the rest mass energy of the infalling matter. The quasar 3C273 has a power output of 3.8×10^{45} ergs/second. If E = mc2 is the formula that converts mass (in grams) into energy (in ergs) and c = the speed of light, 3×10^{10} cm/sec, how many grams/second does this quasar luminosity imply?

Problem 3 - If the mass of the sun is 1.9×10^{33} grams, how many suns per year have to be consumed by the 3C273 supermassive black hole: A) at 100% conversion efficiency? B) At the black hole conversion efficiency of 7%? Note: 7% efficiency means that for every 100 grams involved, 7 grams are converted into pure energy (by $E=mc^2$)

Answer Key:

Problem 1 - The Schwarschild Radius of a black hole is given by the formula R = 2.83 M, where R is the radius in kilometers, and M is that mass of the black hole in units of the sun's mass. A supermassive black hole can have a mass of 100 million times the sun. What is its Schwarschild radius in: A) kilometers B) Multiples of the Earth orbit radius called an Astronomical Unit (1 AU = 147 million kilometers). C) Compared to the orbit of Mars (1.5 U)

Answer: A) R = 283 million kilometers B) 283 million / 147 million = 1.9 AU. C) 1.9/1.5 = 1.3 Mars Orbit. The Event Horizon would be just beyond the orbit of Mars!

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Answer: 3.8×10^{45} ergs/second x (3.1×10^{7} seconds/year) / $(3 \times 10^{10})^2$

= 1.3×10^{32} grams/year

Problem 3 - If the mass of the sun is 1.9×10^{33} grams, how many suns per year have to be consumed by the 3C273 supermassive black hole: A) at 100% conversion efficiency? B) At the black hole conversion efficiency of 7%?

Answer: A) (1.3×10^{32} grams/year) / (1.9×10^{33} grams/sun) = 0.07 suns per year

B) 7% efficiency means that for every 100 grams involved, 7 grams are converted into pure energy (by $E=mc^2$). So,

0.07 suns per year / (7/100) = 1.0 suns per year for 7% efficiency.