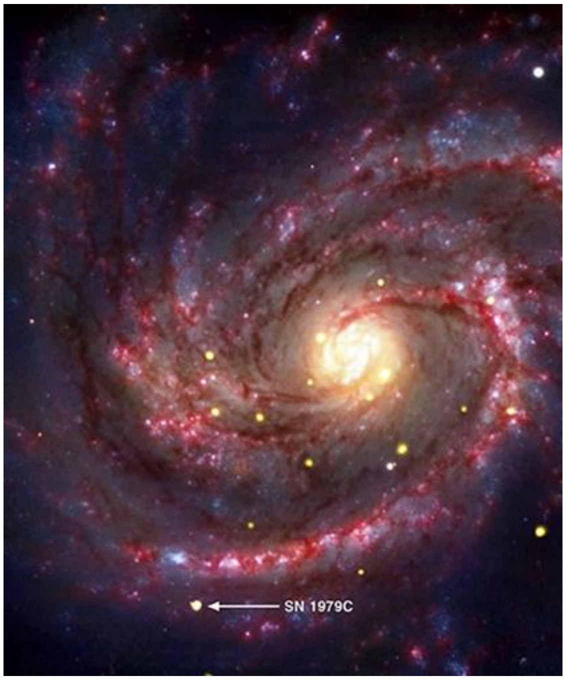

The Chandra X-Ray Observatory recently found evidence for an infant black hole in the nearby galaxy Messiar-100. The black hole is thought to have been produced when a star with a mass of about 20 times that of the sun exploded and left behind a black hole with a mass about 8 times the sun's mass.

The satellite observatory has detected x-rays from the gasses in the orbiting accretion disk that are falling into this young black hole. Infalling gas can be heated to over 100,000,000 K as atoms collide at higher and higher speed during the infall process. The temperature of this x-ray emitting gas is related to its distance from the black hole.

At a distance of R kilometers from a black hole with a mass of M times the sun, suppose that the two equations below relate the temperature of the gas, T, and the wavelength, L, at which the in-flowing gas emits most of its light:

Equation 1 - $T = 100,000,000\left(\frac{M}{R^3}\right)^{1/4}$ Kelvin

Equation 2 - $L = \frac{3,600,000}{T}$ nanometers

where M is in solar mass units, and R is in kilometers.

Problem 1 - Combining these equations using the method of substitution, what is the new formula L(R,M), for the wavelength, L, emitted by the gas as a function of its distance from the black hole center, R, and the mass of the black hole, M?

Problem 2 – X-rays are detected from the vicinity of the SN 1979C black hole at a wavelength of 0.53 nanometers (2,300 electronVolts). If the mass of the black hole is 8 times the sun, at what distance from the center of the black hole is the gas being detected?

Problem 3 – The Event Horizon of a black hole that is not rotating (called a Schwarzschild black hole) is located at a distance of Rs = 3.0 M from the center of the black hole, where M is the mass of the black hole in units of our sun, and Rs is in units of kilometers. What is Rs for the SN 1979C black hole, and where is the x-ray emitting gas in relation to the Event Horizon?

NASA Press release 'Youngest Nearby Black Hole' November 15, 2010

"Data from Chandra, as well as NASA's Swift, the European Space Agency's XMM-Newton and the German ROSAT observatory revealed a bright source of X-rays that has remained steady for the 12 years from 1995 to 2007 over which it has been observed. This behavior and the X-ray spectrum, or distribution of X-rays with energy, support the idea that the object in SN 1979C is a black hole being fed either by material falling back into the black hole after the supernova, or from a binary companion.

The scientists think that SN 1979C formed when a star about 20 times more massive than the Sun collapsed. It was a particular type of supernova where the exploded star had ejected some, but not all of its outer, hydrogen-rich envelope before the explosion, so it is unlikely to have been associated with a gamma-ray burst (GRB). Supernovas have sometimes been associated with GRBs, but only where the exploded star had completely lost its hydrogen envelope. Since most black holes should form when the core of a star collapses and a gamma-ray burst is not produced, this may be the first time that the common way of making a black hole has been observed.

The very young age of about 30 years for the black hole is the observed value, that is the age of the remnant as it appears in the image. Astronomers quote ages in this way because of the observational nature of their field, where their knowledge of the Universe is based almost entirely on the electromagnetic radiation received by telescopes."
(**http://www.nasa.gov/mission_pages/chandra/multimedia/photoH-10-299.html)**

Problem 1 - Answer: Substitute Equation 1 into Equation 2 to eliminate T,

$$L(R,M) = \frac{3,600,000}{100,000,000}\left(\frac{R^3}{M}\right)^{1/4}$$

so $L(R,M) = 0.036\left(\frac{R^3}{M}\right)^{1/4}$ nanometers.

Problem 2 – Answer: $0.53 = 0.036\ (8^{-1/4})\ R^{3/4}$ so solve for R to get

$R = (24.8)^{4/3}$

and so R = **72 km**.

Problem 3 – Answer: The Event Horizon is at Rs = 3.0 x 8 = 24 kilometers. **The x-ray emitting gas is located at R = 72 km, just outside the Event Horizon at a distance of about 48 kilometers.**