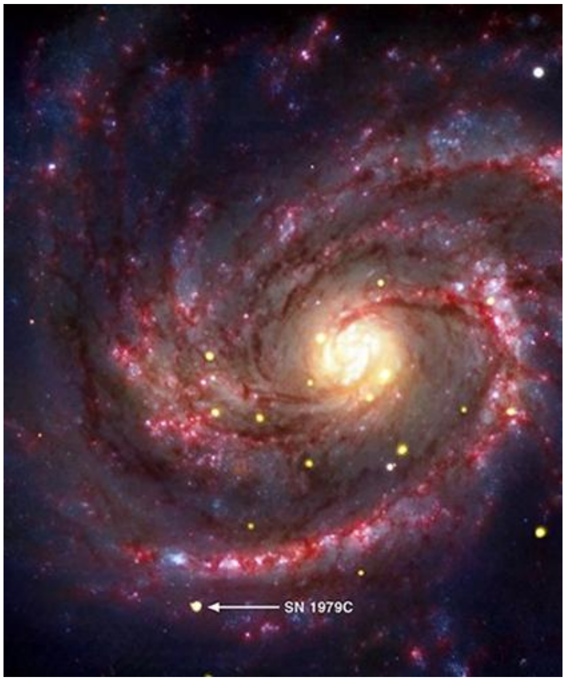
The SN1979C Black Hole



The Chandra X-Ray Observatory recently confirmed the discovery of an infant black hole in the nearby galaxy Messiar-100. The product of the supernova of a star with a mass of 20 times our sun, the resulting black hole may only involve about 8 times our sun's mass.

For black holes that do not rotate, called Schwarzschild Black Holes, there are several different sizes for such black holes that all scale with the mass of the black hole. When referring to the size of a black hole, astronomers usually mention its mass, which is well defined, rather than its diameter, which depends on the specific kinds of physical processes involved.

The Schwarzschild Radius – This is the distance from the center of the black hole at which an incoming person, or light signal, can enter the black hole interior, but cannot emerge back out into the universe. It is also called the Event Horizon. It is a perfectly spherical surface with a radius of Rs = 3.0 M kilometers, where M is the mass of the black hole in multiples of the sun's mass (1 M = 2.0 x 10^{30} kg). For the SN1979C black hole, with an estimated mass of 8 M, what is its Schwarschild Radius, Rs, in kilometers?

Last Photon Orbit – At this distance outside the Event Horizon, an incoming photon of light can enter into an exactly circular orbit, where it will stay until it is disturbed, at which time it will fall into the Event Horizon and never get back out. If Rp =1.5 Rs, what is the radius of the photon orbit for black hole SN1979C in kilometers?

Last Stable Particle Orbit – Inside this distance, a material particle cannot be in a stable circular orbit, but is relentlessly dragged to the Event Horizon and disappears. This occurs at a distance from the black hole center of Rl = 3.0 Rs. How close can a hydrogen atom, an asteroid or a planet remain in a stable circular orbit around the SN1979C black hole?

Problem – An asteroid is spotted at a distance of 700 km from a black hole with a mass of 120 solar masses. Can it escape or remain where it is?

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)**

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Answer: M = 8, so Rs = 3.0 x 8 = **24 kilometers**.

Last Photon Orbit – At this distance outside the Event Horizon, an incoming photon of light can enter into an exactly circular orbit, where it will stay until it is disturbed, at which time it will fall into the Event Horizon and never get back out. If Rp =1.5 Rs, what is the radius of the photon orbit for black hole SN1979C in kilometers?

Answer: Rs = 24 kilometers so Rp = 1.5 x 24 km = **36 kilometers**.

Last Stable Particle Orbit – Inside this distance, a material particle cannot be in a stable circular orbit, but is relentlessly dragged to the Event Horizon and disappears. This occurs at a distance from the black hole center of Rl = 3.0 Rs. How close can a hydrogen atom, an asteroid or a planet remain in a stable circular orbit around the SN1979C black hole?

Answer: R = 3.0 x 24 km = **72 kilometers**.

Problem – An asteroid is spotted at a distance of 700 km from a black hole with a mass of 120 solar masses. Can it escape or remain where it is? Answer: Rs = 3.0 x 120 = 360 kilometers. Rp = 1.5 x 360 km = 540 km; Rl = 3.0 x 360 km = 1080 km. **Since the asteroid is at 700 km, it is inside the distance where it can remain in a stable orbit, so it is about to fall through the black hole's event horizon located some 700-360 = 340 kilometers inside its current position.**