Topic Page: Black holes (Astronomy)

Definition: **black hole** from *Dictionary of Energy*

Physics. an object in space so dense that no light or radiation can escape from it. Black holes, which cannot be observed directly, are believed to be formed when a star collapses inward upon itself.

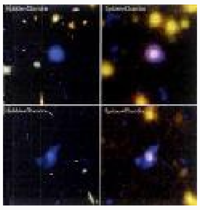

Image from: **Black holes revealed in the Great Observatories...** in *Atlas of the Universe*

Summary Article: **black hole**
From *The Columbia Encyclopedia*

in astronomy, celestial object of such extremely intense gravity that it attracts everything near it and in some instances prevents everything, including light, from escaping. The term was first used in reference to a star in the last phases of gravitational collapse (the final stage in the life history of certain stars; see stellar evolution) by the American physicist John A. Wheeler.

Gravitational collapse begins when a star has depleted its steady sources of nuclear energy and can no longer produce the expansive force, a result of normal gas pressure, that supports the star against the compressive force of its own gravitation. As the star shrinks in size (and increases in density), it may assume one of several forms depending upon its mass. A less massive star may become a white dwarf, while a more massive one would become a supernova. If the mass is less than three times that of the sun, it will then form a neutron star. However, if the final mass of the remaining stellar core is more than three solar masses, as shown by the American physicists J. Robert Oppenheimer and Hartland S. Snyder in 1939, nothing remains to prevent the star from collapsing without limit to an indefinitely small size and infinitely large density, a point called the “singularity.”

At the point of singularity the effects of Einstein's general theory of relativity become paramount. According to this theory, space becomes curved in the vicinity of matter; the greater the concentration of matter, the greater the curvature. When the star (or supernova remnant) shrinks below a certain size determined by its mass, the extreme curvature of space seals off contact with the outside world. The place beyond which no radiation can escape is called the event horizon, and its radius is called the Schwarzschild radius after the German astronomer Karl Schwarzschild, who in 1916 postulated the existence of collapsed celestial objects that emit no radiation. For a star with a mass equal to that of the sun, this limit is a radius of only 1.86 mi (3.0 km). Even light cannot escape a black hole, but is turned back by the enormous pull of gravitation.

It is now believed that the origin of some black holes is nonstellar. Some astrophysicists suggest that immense volumes of interstellar matter can collect and collapse into supermassive black holes, such as are found at the center of large galaxies. The British physicist Stephen Hawking has postulated still another kind of nonstellar black hole. Called a primordial, or mini, black hole, it would have been created during the “big bang,” in which the universe was created (see cosmology). Unlike stellar black holes, primordial black holes create and emit elementary particles, called Hawking radiation, until they exhaust their energy and expire. It has also been suggested that the formation of black holes may be associated with intense gamma ray bursts. Beginning with a giant star collapsing on itself or the collision of two neutron stars, waves of radiation and subatomic particles are propelled outward from the nascent black hole and collide with one another, releasing the gamma radiation. Also released is longerlasting electromagnetic radiation in the form of X rays, radio waves, and visible wavelengths that can be used to pinpoint the location of the disturbance.

Because light and other forms of energy and matter are permanently trapped inside a black hole, it can never be observed directly. However, a black hole can be detected by the effect of its gravitational field on nearby objects (e.g., if it is orbited by a visible star), during the collapse while it was forming, or by the X rays and radio frequency signals emitted by rapidly swirling matter being pulled into the black hole. The first discovery (1971) of a possible black hole was Cygnus X-1, an X-ray source in the constellation Cygnus. In 1994 astronomers employing the Hubble Space Telescope announced that they had found conclusive evidence of a supermassive black hole in the M87 galaxy in the constellation Virgo. Since then others have been found, and in 2011 astronomers announnced the discovery of one, in NGC 4889 in the constellation Coma, whose mass may be as great as 21 billion times that of the sun. The first evidence (2002) of a binary black hole, two supermassive black holes circling one another, was detected in images from the orbiting Chandra X-ray Observatory. Located in the galaxy NGC6240, the pair are 3,000 light years apart, travel around each other at a speed of about 22,000 mph (35,415 km/hr), and have the mass of 100 million suns each. As the distance between them shrinks over 100 million years, the circling speed will increase until it approaches the speed of light, about 671 million mph (1,080 million km/hr). The black holes will then collide spectacularly, spewing radiation and gravitational waves across the universe. The Chandra observatory has also discovered that massive black holes were associated with galaxies that existed 13 billion years ago. Subsequently, the Laser Interferometer Gravitational Wave Observatory (since 2015) and the European Gravitational Observatory (since 2017) several times have detected gravitational waves that resulted from the merging of other black hole pairs.

See Hawking, S. W. , Black Holes and Baby Universes and Other Essays (1994);.
Strathern, P. , The Big Idea: Hawking and Black Holes (1998);.
Wheeler, J. A. , Geons, Black Holes, and Quantum Foam: A Life in Physics (1998);.
H. Falcke; F. W. Hehl, The Galactic Black Hole: Studies in High Energy Physics, Cosmology and Gravitation (2002);.
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