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## EXPLODING STARS, PULSARS AND BLACK HOLES IN SPACE

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# EXPLODING STARS, PULSARS AND BLACK HOLES IN SPACE

## Supernovas

A supernova is a large star at life's end, whose final collapse is a cataclysmic event that generates a violent explosion, blowing the innards of the star out to space. There the material of the exploded star mixes with the primeval hydrogen of the universe. Later in the history of the galaxy, other stars are formed out of this mixture. The Sun is one of these stars; it contains the debris of countless others that exploded before the Sun was born. The last supernova observed in the Milky Way Galaxy -- of which our solar system is a part -- was seen by Johannes Kepler in 1604. Supernova explosions, resulting in neutron stars and black holes, occur with massive stars; stars smaller than, say, our Sun -- which is an average-sized star, probably become white dwarfs.

## Pulsars and Neutron Stars

Discovered in 1967, pulsars emit radio signals whose pulsations are extremely precise. The evidence suggests that pulsars are fast-spinning neutron stars.

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These are compact bodies of densely packed neutrons (atomic particles having no electric charge), believed to form when a large star burns up its fuel and collapses. Containing the mass of a star in a sphere 10 miles in diameter, they are so closely packed that a spoonful of material from the center would weigh a billion tons. A neutron star, or pulsar, has been located in the center of the Crab Nebula, a glowing cloud which is still expanding from a supernova reported by the Chinese in 1054.

Black Holes

Believed to be the final stage in the collapse of a dying star which was very massive. The collapsed star's material is so densely packed -- even more so than a neutron star -- and the gravitational force so great that even light waves are unable to escape from the surface of a black hole. All external evidence of its presence disappears. Because black holes emit no light or other radiation, their existence -- predicted by the laws of relativity -- cannot be confirmed by direct observation, but it can be inferred. Astronomers have identified a powerful X-ray source in the constellation Cygnus. Some suspect the source, which has been labeled Cygnus X-1, may be just such a black hole.

It appears to be rotating with a visible star around a common center of gravity. Scientists believe material from the glowing star is being drawn into the black hole with such force that the material becomes hot enough to emit X-rays.

Red Giant

An aging star approaching the end of its life. The beginning of the end comes when the star has exhausted much of the hydrogen near its core and starts to burn the hydrogen in its outer layers. This process causes the star to gradually turn red and swell to 100 times its previous size, pouring out prodigious amounts of energy. Betelguese, in the constellation Orion, is such a red giant visible to the naked eye. What happens after its hydrogen is consumed depends on the size of the star. A small star contracts and becomes a white dwarf. A large star becomes a supernova, blowing its innards into space.

White Dwarf

A small aging star in the final stages of its life. Having exhausted all its hydrogen, the star cannot generate sufficient pressure at its center to balance the crushing force of gravity. The star collapses under the force of its own weight and remains collapsed.

Such a collapsed star, at its life's end, is called a white dwarf. (In a large star, the final collapse generates the supernova explosion outlined earlier.) White dwarfs contract to about the size of the Earth, a few thousand miles in diameter, and then spend many years gradually losing their heat. Eventually, the white dwarf's fires burn out entirely, leaving behind a black dwarf.

Quasars

Astronomers are still baffled by the nature of quasars, but many believe that among observable objects they are the most remote in the universe. They look like stars when viewed through an optical telescope, but emit more energy at radio frequencies than the most powerful galaxies known. According to calculations, if they are as distant as many astronomers think they are, the total amount of energy emitted by a quasar in one second ($10^{47}$ ergs/sec) would supply all of Earth's electrical energy needs for a billion years.

Radio Galaxies

Located on the fringes of visibility, they emit radio waves millions of times more powerful than the emissions of a normal spiral galaxy. No one knows what these peculiar galaxies are. Several of them broadcast with such huge power that a sizeable fraction of the nuclear energy locked up in their matter must be going completely into the production of radio waves.

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