Neutron Stars, Pulsars, Millisecond Pulsars, and Gravitational Radiation:

GLOSSARY

Accretion disk: The flattened, pancake-like structure formed by matter that is being drawn gravitationally onto a central star -- such as matter captured from an ordinary stellar companion onto a neutron star or a black hole. As matter drifts inward toward the neutron star or black hole, it is heated up viscous forces, releasing electromagnetic radiation, including X rays.

Accretion-powered pulsar: X-ray binary pulsars whose pulses are generated by the accretion flow striking the neutron star. Instead of falling uniformly onto the neutron star, the steady flow (accretion) of matter from the companion star is channeled by the pulsar's magnetic field onto the magnetic poles of the neutron star, resulting in a pair of "hot spots" on the pulsar surface. As the pulsar spins, these hot spots are brighter in X-rays than the rest of the star, giving rise to X-ray pulsations at the spin rate. In accretion-powered millisecond pulsars, the magnetic field (and thus the channeling) is relatively weak, so that the pulsations can be difficult to detect.

Binary pulsar: see Accretion-powered pulsar.

Binary star: a pair of stars that are gravitationally bound and in orbit about each other.

Black hole: An object whose gravitational pull inside a certain radius is so strong that nothing, not even light can escape it. A black hole forms when the amount of matter in the core of a star undergoing a supernova is great enough to cause a runaway gravitational collapse.

Burst oscillation: Periodic fluctuations in X-ray brightness (intensity) observed during an X-ray burst (a thermonuclear explosion on the surface of an accreting neutron star). Now understood to be nuclear-powered pulsations at the spin rate of the neutron star. (see also Nuclear-powered pulsar.)

Einstein's theory of general relativity: The theory of gravitation developed by Albert Einstein that describes how matter (or, anything possessing mass) alters (or, warps) both the space and time around it. Einstein also developed the theory of special relativity, which describes the motion of objects near the speed of light. One of the key predictions of general relativity is the existence of gravitation waves.

Electromagnetic radiation (or waves): Fluctuations of electric and magnetic fields that depending on their frequency take the form of visible light, radio waves, or X rays, among others. The photon is the carrier of electromagnetic radiation.

Gravitational waves (radiation): Predicted by Einstein's theory of general relativity but so far only indirectly detected, these are the ripples or distortions of space-time produced by the motion of matter. Indirect detection of gravitational waves came from the discovery in 1974 that two pulsars in orbit around each other (PSR 1913 + 16) are gradually getting closer by exactly the amount predicted if the two objects were emitting gravitational waves. Direct detection of gravitational waves may come from future ground and space-based missions now being developed.

Isolated pulsar: see Rotation-powered (radio) pulsar

Millisecond pulsar: A pulsar with a rotation period of 1 to 10 milliseconds, or equivalently a spin rate between 100 and 1,000 revolutions per second. The fastest known millisecond pulsar (PSR 1937 +21) has a period of 1.6 milliseconds, meaning it is rotating 640 times per second.

Neutron star: The collapsed core of a massive star remaining after a supernova explosion. Usually, the core will have a mass of 1.4 times that of the Sun and a diameter of about 10 miles. Because matter is compressed so tightly, negatively charged electrons and positively charged protons are forced together. The resulting star consists of a core of superfluid neutrons and superconducting protons encased by a solid crystalline crust.

Nuclear-powered millisecond pulsar: A millisecond pulsar whose X-ray pulses are generated by burst oscillations lasting only a few seconds during type I X-ray bursts. These bursts are caused by thermonuclear explosions that rapidly consume the accreted material that has collected on the neutron star surface. At least one millisecond pulsar, SAX J1808.4-3658, is both nuclear-powered and accretion-powered. (See also Burst oscillations, X-ray burst. Compare to accretion-powered millisecond pulsar.)

Pulsar: A rotating neutron star that generates regular pulses of radiation at its spin rate. Pulsars were discovered by observations at radio wavelengths but have since been observed at optical, X-ray, and gamma-ray energies. The term comes from "pulsating radio source" since they were first observed at radio frequencies. Pulsars may be divided in three groups: rotation-powered pulsars, accretion-powered pulsars, and nuclear-powered pulsars.

Roche lobe: The maximum volume of star within which material is gravitationally bound to the star, when the star is part of a binary system. If the distance between the two stars is sufficiently small, the Roche lobe can become smaller than the actual volume of one of the stars, causing its matter to be gravitationally captured by the other star via an accretion disk. If the other star is a neutron star or black hole, such a system is called an X-ray binary. See also Accretion disk, Binary star, X-ray binary.

Rotation-powered pulsars: Pulsars (in general, isolated radio pulsars) with powerful magnetic fields that cause accelerated charged particles to emit radiation. This radiation is channeled into two conical-shaped regions centered about the pulsar's magnetic poles (which are not aligned with the pulsar's axis of rotation). As these conical-shaped regions sweep through space -- much like a lighthouse beam -- they produce the pulses of electromagnetic radiation that are the hallmark of pulsars.

Spin frequency: The rotation rate of a spinning object, equal to the number of revolutions per second.

Supernova: The explosion caused when a massive star, at least 8 times the Sun's mass, dies (exhausts its fuel) and collapses. If the original star is less than 20 solar masses, the supernova will leave behind a neutron star. Heavier stars will collapse into black holes. Supernova explosions are among the most energetic events in the Universe, and they forge the heavy elements such as carbon, oxygen, and silicon.

X-ray binary: A neutron star or black hole accreting matter from a normal stellar companion via an accretion disk. The accretion flow is usually generated when close orbit of the binary causes the normal star to overfill its Roche lobe and spill into the accretion disk. The material in the accretion disk heats up and emits X-rays. If the central object is a neutron star, then X-rays are also emitted when the accretion flow strikes the neutron star surface. If the neutron star's magnetic field is sufficiently strong, it will channel the flow onto the magnetic poles, giving rise to an accretion-powered pulsar.

X-ray burst: A bright, sudden flash of X-rays from an accretion neutron star, typically lasting only 10-100 seconds. These bursts are caused by thermonuclear explosions on the surface of the neutron star. The explosion consumes the accreted material that has accumulated on the surface, causing a hot spot that spreads from the place of ignition. This hot spot can give rise to burst oscillations at the spin rate of the neutron star. (See also Burst oscillations, Nuclear-powered pulsar.)

X rays: A type of electromagnetic radiation with a very short wavelength (or conversely, a very high frequency).