Astronomy Bizarre | Wheeler
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Review for Test #3
Supernova 1987A, Neutron Stars, Einstein's Gravity

Supernova 1987A

- The first supernova observable by the naked eye in about 400 years. It is directly observable only in the southern hemisphere.
- Large Magellanic Cloud – small irregular satellite galaxy about 170,000 light years from the Milky Way, the site of the explosion of Supernova 1987A.
- 30 Doradus or the Tarantula Nebula – the glowing region of new star formation near the site of the explosion of SN 1987A.
- SN 1987A was detected in radio, infrared, optical, ultraviolet, X-ray, and gamma ray bands of the electromagnetic spectrum.
- The star that exploded was a blue super giant. There was initial confusion over the identity of the star that exploded. Two stars are visible in photographs taken before the supernova, and two stars were still detected by satellite in the ultraviolet after the explosion. There originally were three stars in the same vicinity.
- Neutrinos were detected, proving that SN 1987A underwent iron core collapse to form a neutron star. No neutron star has been detected. Dim compact object in Cas A might be related. A black hole is still a possibility.
- Light Curve of SN 1987A – Shock breakout in first day. Subsequent peak and tail of the curve are explained by energy of radioactive decay.
- Rings – The rings around SN 1987A were created by the star before it exploded, perhaps when it consumed a companion star. The ejecta of the supernova have begun to collide with the ring.
- Jets – The shape and motion of the matter ejected by SN1987A are roughly consistent with the expanding "breadstick and bagel" configuration expected from the model of jet-induced supernovae.

Neutron stars – mass of sun, radius ~ 10km, density like atomic nucleus, huge gravity at surface

Discovery of pulsars – pulsating radio sources

Interpretation of pulsars as rotating magnetized neutron stars.

Role of magnetic field to cause radiation, misalignment of rotation axis, magnetic axis

Production of pulses – probably related to strong electric, magnetic fields at magnetic poles.

About 2000 pulsars known (600 in book is outdated), perhaps a billion neutron stars in the Galaxy

Pressure support from quantum pressure, of neutrons, plus nuclear repulsion. Maximum mass of neutron star is about 2 solar masses.

Neutron stars as binary X-rays sources.

X-ray pulsars – accreted gas channeled to magnetic poles, "pulsar" by lighthouse effect if magnetic axis is tilted with respect to the spin axis

Magnetars – neutron stars with magnetic fields 100 to 1000 times stronger than the Crab nebula pulsar.

Soft gamma-ray repeaters – objects that emit intense bursts of low energy gamma rays and X-rays for a few minutes every few years. Periodic "pulses" after the initial flash. Observed spin-down rates imply they are magnetars. One soft gamma-ray repeater actually caused aurorae and interfered with terrestrial radio communications August 1998, another flared on the far side of our Galaxy, and was detected on December 27, 2004.

Black Hole History – Mitchell, Laplace, escape velocity.

Conceptual problems with Newton's Theory of Gravity

Einstein says there is no "force" of gravity. Matter curves space and curved space tells matter how to move.

Dimension – determined by the number of mutually perpendicular directions in a given space

Space versus Hyperspace

Parallel propagation – the process of constructing a straight line; by extending a line segment parallel to itself. Guaranteed to produce the shortest distance between starting, ending points. Works in curved as well as flat space.

The nature of the curvature of a space in two, three (or higher) dimensions can be determined by doing geometry.

Three-dimensional space is regarded as "flat" if the result of doing geometry is the same as in ordinary flat two-dimensional space (sum of interior angles of triangles is 180 degrees, parallel lines remain parallel). If flat space geometry does not apply, the space is curved, or non-Euclidian.

Embedding diagram – a method of reducing a three (or higher) dimensional space to two-dimensional space that preserves the basic geometry and curvature of the original space. This allows us to "see" the curvature.

Einstein says the space around a gravitating object (Earth, a star, a black hole) is curved in the same sense as a cone poked in a rubber sheet. The circumference of a circle drawn around such an object is less than 2π times the radius and "straight lines," parallel propagated, the shortest distance between two points, curve around the object. One type of straight line in this kind of curved space follows the curved space and closes on itself. An orbit is interpreted as this kind of straight line.

Event Horizon – Since nothing with velocity less than or equal to the speed of light can pass backward through an event horizon, the information that an event occurred cannot pass through, so an event on the wrong side of an event horizon can never be known to an observer on the opposite side, hence the name.

Singularity – region in center of black hole where ordinary space and time cannot exist because of severe space time curvature and quantum uncertainty. The boundary of physics as we currently know it.

Tidal forces tend to draw any object into a "noodle" shape for two reasons: the force closer to the center is stronger and because two separated points the same distance from the hole tend to approach one another as they both try to fall directly toward the center.

Far away from a gravitating object, space is "flat" and there is no gravity. Black holes are "safe" from a distance.