Astronomy Bizarre
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Review for Test #3
Supernova 1987A and Neutron Stars

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 150,000 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 gamma rays from Nickle-56 and Cobalt-56 as they decay to form iron. Gamma rays, high-energy photons, were also directly observed by satellite.
- 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 "bun and bagel" configuration expected from the model of jet-induced supernovae. The "bun" is nearly perpendicular to the rings and the "bagel" is expanding in the plane of the inner ring.

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 (i.e. not pulsation, not white dwarfs)

Importance of pulsar in Crab Nebula — fast period, not a white dwarf.

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, ejection of electrons, annihilation of positrons

Magnetic fields cause particles to move like beads on a wire. At a certain distance, the speed of light cylinder, the magnetic fields will bend, rip and radiate.

About 600 pulsars known, perhaps a billion neutron stars in the Galaxy.

Structure — iron-like crust, superfluid neutron center

Glitches — temporary speeding-up of pulse rate — clue to superfluid core

Pressure support from quantum pressure of neutrons plus nuclear repulsion. Maximum mass of neutron star about 2-3 solar masses.

Binary radio pulsars — determine motion from Doppler shift of pulse rate, derive mass of neutron star and observe orbital decay from gravitational radiation.

Neutron stars as binary X-rays sources.

X-ray pulsars — accreted gas channeled to magnetic poles, neutron star spins faster as it accretes.

X-ray transients — 4 or 5 in Galaxy. Outburst every few years for a month. Probably a disk instability like a dwarf nova, but with the white dwarf replaced by a neutron star.

X-ray Bursters — about 30 in the Galaxy. Burst every few hours for minutes. Probably the neutron star analog of a classical nova. Matter accretes on surface of neutron star. Hydrogen is supported by thermal pressure, burns to helium. Helium is supported by quantum pressure and is unregulated and explodes. Often found in globular clusters.

Millisecond pulsars — rotating near breakup speed for neutron stars, about 1000 times per second, but old, not young. Probably born in a binary, spun up by mass accretion. Low magnetic field so small energy loss, slow spin-down. Companion often accreted away.

Binary millisecond pulsar — black widow system, the pulsar emits gamma rays which are helping to erode, destroy the companion star. Perhaps why most millisecond pulsars are observed as single pulsars.

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 gamma rays and X-rays for a few minutes every few years. Observed spin-down rates imply they are magnetars. One soft gamma-ray repeater actually caused aurorae and interfered with terrestrial radio communications August, 1998.

Geminga — nearby neutron star, about 500 light years away, 350,000 years old.