Astronomy Bizarre
309N Spring 2015
(47365)

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April 13, 2015

Review for Test #4
Neutron Stars, Gravity, Black Holes

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

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

Discovery of pulsars – pulsating radio sources

About 2000 pulsars known (600 in book is outdated), perhaps a billion neutron stars in the Galaxy

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, thunderstorms and static.

Speed of Light Circle – distance from neutron star rotation axis at which magnetic field lines would drag plasma at the speed of light. Magnetic field would break, yielding radiation.

Gamma-rays from pulsars – may arise from the speed of light circle, carry most of the power radiated.

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 within 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.

Nature of Time in the vicinity of a black hole. Any observer always senses his or her own time as perfectly normal, but an observer at a large distance from the black hole where the force of gravity is small sees time passing more slowly for events occurring deep in the gravitational field of a black hole. Events right at the event horizon would show no passage of time to a distant observer. A distant observer watching another person falling toward the event horizon would perceive (other effects not interfering) that this second person gradually approached but never crossed the event horizon. An observer freely falling under the influence of no forces would plunge into the black hole after a finite (and normally short) passage of their own time.

Redshift—the redshift of the wavelength of photons received at a distance gets very large as the point of emission of the photon gets deeper in a gravitational field.

“Black Hole”—the large redshift of photons emitted near the event horizon coupled with the long passage of time between the arrival of these photons at a distant observer due to the apparent slowing of time means events happening just outside the event horizon cannot, in practice, be “seen” by a distant observer, —hence, a “black hole.”