Wednesday, March 29, 2017

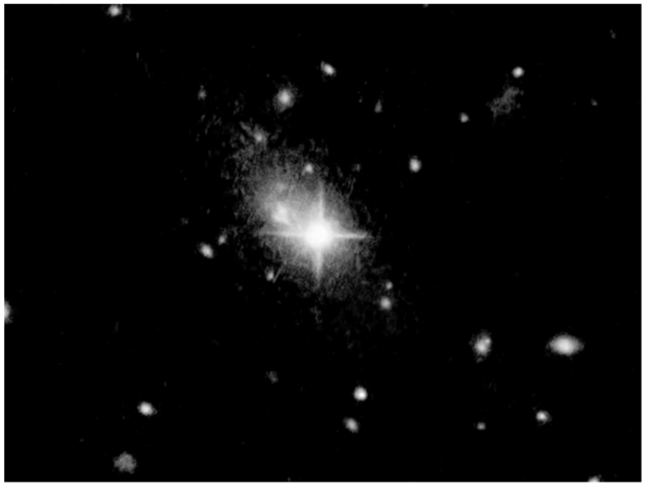
***Third exam, Skywatch, Friday, March 31.***

**Review Sheet Posted. Exam review Thursday, 5 – 6 PM, WEL 2.308.**

Reading for Exam 3: Chapter 6, end of Section 6 (binary evolution), Section 6.7 (radioactive decay), Chapter 7 (SN 1987A), Background: Sections 3.1, 3.2, 3.3, 3.4, 3.5, 3.8, 3.10, 4.1, 4.2, 4.3, 4.4, 5.2, 5.4 (binary stars and accretion disks) plus superluminous supernovae.

Astronomy in the news

Gravitational waves likely ejected a supermassive black hole from the center of galaxy 3C186 when it merged with another supermassive black hole. It took the equivalent energy of 100 million supernovae exploding simultaneously to jettison the black hole.



# Goals:

To understand how Einstein taught us to think about space, time, and gravity.

To understand what we mean by space.

To understand how space can be curved.

Can 3-dimensional space be “flat?”

Yes, it can be flat or curved, just as 2-dimensional space can.

3-dimensional space is regarded as flat if the result of doing geometry is the same as ordinary flat two dimensional space, the 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.

**Can 4-dimensional space be flat?**

One Minute Exam

In a curved space:

⇨ Straight lines always connect to themselves

⇦ Straight lines are the shortest distance between two points

⇧ There are no straight lines

⇩ The sum of the interior angles of a triangle is 180 degrees

One Minute Exam

Compared to the two-dimensional surface of a balloon, the inside of the balloon is:

⇨ A two-dimensional hyperspace

⇦ A three-dimensional hyperspace

⇧ A four-dimensional hyperspace

⇩ Accessible to a two-dimensional creature

One Minute Exam

An intelligent ant crawls around on a surface, drawing triangles as the intersection of 3 straight lines. She finds that the sum of the interior angles is always more than 180 degrees and that triangles of the same size always give the same results. She deduces that the following will be true:

⇨ If she draws two straight lines that are initially parallel they will begin to diverge.

⇦ The surface she is walking on is three-dimensional

⇧ If she walks off in a straight line she will never return to her point of origin

⇩ If she walks off in a straight line she will return to her point of origin

# Goal:

To understand the nature of curved space, and hence of gravity, in the vicinity of a massive object, a planet, star, or black hole.

To understand the role of an "embedding diagram" in helping to explain that curved space.

Embedding diagram: Removes one dimension, but preserves key aspects of the geometry, curved or not, and how curved.

| | | |
|---|---|---|
| Real Space | -> | Embedding Diagram Space |
| Volume (3D) | -> | Surface (2D) |
| Surface (2D) | -> | Line (1D) |
| Line (1D) | -> | Point (0D) |

Embedding diagrams allow us to visualize some aspects of the curvature of space from a higher dimensional "hyperspace" perspective.

Invert balloon - 2 D embedding diagram of curved 3 D space around gravitating object

Properties of this curved space that are preserved in the embedding diagram and are **true in the original 3D space**:

$C < 2\pi r$

Sum of angles of triangle not equal 180º (can be > or <)

Parallel lines diverge or cross

Orbits around “cone”

Far from a gravitating object, the curvature and hence gravity, gets very weak, 3D space becomes FLAT, and the corresponding embedding diagram is a flat 2D plane (can’t show this with the balloon).