Lecture 17: General Relativity and Black Holes

Schedules

- ***Lecture #15 (May 22 , tuesday)***
  - *Topic: Stellar Death, History of Planetary Nebula (chap 19)*
  - *Quiz 3 on Sun, Nuclear, Astrophysics, Stellar Birth and some quiz 2 repeats*
- ***Lecture #16 (last time, May 24, thursday)***
  - *Topic: XII. Stellar Death (Planetary Neb, Supernova, White Dwarfs, chap 20)*
  - *Topic: Pulsars & Neutron stars (Chap 21)*
  - *Topic: Special Relativity (video: mechanical universe #42 Lorentz Transformation)*
- **Lecture #17 (today, May 29, Tuesday)**
  - *Practice Slides of Galaxies (see list at end of handout)*
  - Topic: General Relativity, Black Holes (chap 22)
  - Video: Monster Black hole in the Milky Way (tentative)
  - Topic: Milky Way (Chap 23)
- **Lecture #18 (next time May 31, Thursday)**
  - Topic: XIII. Milky Way (Chap 23)
  - Topic: Hubble's Law, Galaxies (chap 24), start but will not finish.
  - Office Hours: I may be around on Thursday due to other commitments cancelled
- **Lecture #19 (June 5, Tuesday)**
  - ***Quiz 4*** *on Stellar Midlife (Chap 19), Death (Chap 20), White dwarfs and Neutron stars (Chap 21) and Relativity & Black Holes (Chap 22). Will also include Milky Way (chap 23). NO slides!*
  - ***Transit of Venus starts around 3 pm our time, ending at sunset 8:25 pm.***

Notes:

- New Office Hours: Tue/thur after class for rest of quarter
- Einstein@Home: Help prove Einstein's theories about gravity by donating some of your home computer's processing time. http://www.einsteinathome.org/

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QUESTIONS on: Stellar EVOLUTION: (included on Quiz 4)

1. Which is NOT true for stars in an open cluster:
   a. born at same time b. about same distance away
   c. all same spectral class d. show a main sequence line on HR e. none of these
2. Which is NOT true for stars in a globular cluster
   a. born at same time b. shows a main sequence line on HR
   c. about same distance away d. has some O & B stars e. none of these
3. Main sequence lifetime of the sun in years? _____
4. Type of star found in an emission nebula? _____
5. Type of variable associated with pre-main sequence? _____
6. Most stable nuclei in the universe is? _____

7. Essay Questions: How about an H-R diagram and have you label features? Or show the evolution of the sun? Or maybe the formation of the sun?

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Some QUESTIONS on: Stellar Death (Quiz 4)

6. A white dwarf star does not does not collapse any smaller because of
   a. electron degeneracy b. radiation pressure c. gravitational pressure
   d. neutron degeneracy e. centrifugal force from the high rotation rate

3. The dominant energy producing reaction in a white dwarf is:
   a. carbon fusion b. gravitational contraction
   c. triple alpha d. proton-proton fusion e. none of these

4. The final stage of a lightweight star (like the sun) is probably a,
   a. black hole b. white dwarf c. neutron star d. pulsar e. none of these

5. Which probably has the fastest rotation rate?
   a. sun b. red giant c. white dwarf d. neutron star e. none of these

E2. Briefly, what is a supernova, how do they behave, and why do observers search the skies for them?

E4. What is the observational evidence for a Neutron star? White dwarf?, Black Hole?

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Sample Quiz Questions on Relativity and black holes (Quiz 4)

1. Fred Berfle is moving past you at high speed. To you, his watch is running ____ yours.
   a. slower than b. faster than c. at the same rate as

2. According to the special theory of relativity, all laws of nature are the same in reference frames that,
   a. accelerate b. move in circles c. oscillate
   d. move at constant velocities e. none of these

3. Luke Skywalker standing on the ground sees a space ship move past at 95% the speed of light. Compared to when he saw the spaceship earlier on the ground being fixed, Luke sees the length of the moving spaceship as,
   a. longer b. shorter c. the same length as

4. A spaceship fires a laser cannon (i.e. photons which move at the speed of light=c) in the forward direction. If the spaceship is moving away from the earth at 20% the speed of light (0.2c) how fast are the photons moving relative to the earth?
   a. 1.5 c b. 1.2 c c. 1.0 c d. 0.8 c e. none of these

37. Which is NOT a prediction of Einstein's general/special relativity?
   a. light will be bent by a gravitational field
   b. the spectral lines of an atom will be discrete
   c. light will be redshifted pulling away from a star
   d. the speed of light can not be exceeding e. none of these

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Review Questions on Milky Way (chapter 23). Include on Quiz 4

38. In the center of our galaxy there is probably:
    a. globular cluster b. black hole c. open cluster
    d. another small galaxy e. none of these

33. The approximate number of stars in our galaxy? _____

24. The approximate diameter of our own galaxy? _____

25. The galactic north pole is in what constellation? _____

1. The Sun is located at the center of the Milky Way Galaxy. True or false

2. Shapley overestimated the dimensions of the Milky Way Galaxy because he failed to account for interstellar extinction by dust. True or false

3. The Herschels attempted to determine the galaxy's structure by
    (a) looking for dust clouds with their telescope
    (b) locating the galactic center.
    (c) correct systematically counting stars in each direction
    (d) observing globular star clusters
    (e) finding the distances to the spiral arms.

4. Shapley was able to determine the distance to a globular star cluster by identifying and studying each cluster's
    (a) RR Lyrae stars
    (b) Population I stars
    (c) eclipsing binaries
    (d) spectroscopic binaries
    (e) gas and dust

5. Modern representations of the galaxy place Population II stars
    (a) only in the halo
    (b) only in the disk
    (c) in the halo and the central bulge
    (d) only at galactic center

1. Although space telescopes provide better quality observations, Earth-based telescopes are able to observe the galactic center very well. True or false

2. A spin-flip transition occurs spontaneously simply because nature does not like to be in a higher-energy state. True or false

3. Stellar densities are much higher near the galactic center than in most of the disk. True or false

4. Stellar orbital speeds at the center of the galaxy are 10-100 times greater than the Sun's velocity. True or false

5. Dust emits mainly in the
    (a) radio (b) far-infrared (c) near-infrared (d) visible.

6. Which of the following best describes the disk of the galaxy as seen in the infrared?
    (a) long and thick long and asymmetrical (b) long and thin long and clumpy

7. Observations at which wavelengths indicate we live in a barred galaxy?
    (a) radio (b) infrared (c) optical (d) X-ray

8. Why does Sag A have lobes of hot gas located 180 degrees apart, instead of a spherical distribution of hot gas surrounding it?
Answer: Sag A has _____
(a) an equatorial accretion disk (b) has strong, asymmetrical winds
(c) no magnetic field (d) an eccentric orbit.

9. Which of the following is not a piece of evidence that there is a supermassive black hole at the center of the Milky Way?
(a) Stars near the center of the galaxy have very small orbits and very high orbital speeds
(b) X-ray flares detected from Sag A* have very short variation timescales.
(c) Infrared observations indicate there is a bar at the galactic center.
(d) is a very strong source of X-ray and synchrotron emission.

10. Observations at which of the following wavelengths indicate that Sag A has a very strong magnetic field?
(a) radio (b) infrared (c) optical (d) X-ray

11. The galactic halo is dominated by Population II stars, whereas the galactic disk contains predominantly Population I stars. In which of these parts of the galaxy has star formation taken place more recently?
(a) Population II stars are younger than Population I stars, indicating that star formation has taken place more recently in the halo.
(b) Population I stars are younger than Population II stars, indicating that star formation has taken place more recently in the disk.

Galactic Objects (for Final)

NAME	Cat#	Const.	Type of Object & Misc Info	Book*
Milky Way			Our Galaxy	
Large Magellanic Cloud	LMC	Dorado/Mensa	Irreg Comp. to Milky Way	643
			[has Tarantula Nebula]	540 643
Small Magellanic " "	SMC	Tucana	Irreg. Companion to Milky	665
Andromeda	M31	Andromeda	Spiral Galaxy type Sb	637
[Companion to M31]	M32	" "	Dwarf Elliptical Companion	132, 637
" "	M110	" "	" "	637
Triangulum Galaxy	M33	Triangulum	Face-on Spiral Type Sc	-----
Whirlpool Galaxy	M51	Canes Venatici	Spiral type Sc (pec)	636
BlackEye Galaxy	M64	Coma Berenices	Spiral type Sb	-----
Sombrero Galaxy	M104	Virgo	edge on Spiral(Sa)(NGC4594)	
Pinwheel	M101	Ursa Major	Spiral type Sc	
Bode's Galaxy	M81	Ursa Major	Spiral type Sb	640, 655
Cigar Galaxy	M82	Ursa Major	Irr(pec) companion to M81	655
Southern Pinwheel	M83	Hydra *	Spiral type SBb?	640
Centaurus A	----	Centaurus	Radio Galaxy [E pec]	666, 677
The Antennae	?	?	Rat-tail radio galaxy	
[in virgo cluster]	M87	Virgo	Giant E0-pec (radio jet)	676
Super Clusters			[clusters of galaxies]	
The Cartwheel			A ring galaxy	---

**Page numbers in Freedman & Kaufmann, 9th ed "Universe"*