Astronomy 102 — Recitation 1

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Review of the first lecture and the book's Prologue.

Unit conversions

- 1 ly $= 9.46 \times 10^{17}$ cm
- 1 AU $= 1.58 \times 10^{-5}$ ly $= 1.50 \times 10^{13}$ cm
- $1M_{\odot} = 2.0 \times 10^{33}$ g
- 1 yr $= 3.16 \times 10^{7}$ s
- $c = 3.0 \times 10^{10}$ cm/s

Typical...

- Lengths and distances
  - Diameter of normal stars: millions of km
  - Diameter of normal galaxies: tens of kly
  - Distance between stars in a galaxy: a few ly
  - Distance between galaxies: a million ly
- Masses
  - Smallest stars: $0.08M_{\odot}$
  - Normal stars: about $1M_{\odot}$
  - Giant stars: tens of $M_{\odot}$
  - Normal galaxies: $10^{11} - 10^{12}M_{\odot}$
  - Galaxy clusters: $10^{14} - 10^{15}M_{\odot}$
- Time spans
  - Planetary revolution period: around 1 yr
  - Life expectancy for normal stars: around 10^{10} yr
  - Life expectancy for giant stars: $10^{6} - 10^{8}$ yr
  - Rotation period of normal galaxies: $10^{7} - 10^{9}$ yr
- Speeds
  - Planetary orbits in a Solar System: tens of km/s
  - Stellar orbits in a normal galaxy: hundreds of km/s
  - Speed between nearby galaxies: hundreds of km/s

Solar-mass sized black hole

- Black holes are highly gravitating objects from which nothing (not even light) can escape.
- Interstellar travel takes less time for those on board the space ship than for those left behind on Earth — example of length contraction.

In-class problems

1. Take a look at the animation found at `http://htwins.net/scale2/` to probe the different length scales encountered in the Universe.
2. Convert the following values:
   (a) 125 seconds to days
   (b) 7.5 years to seconds
   (c) c to ly/yr
   (d) 4.2 ly to cm
   (e) 8.6 $M_\odot$ to g
   (f) 521 km/s to ly/yr
3. For someone who lives on Jupiter, their year is equal to 11.862 Earth years. At a distance of 5.2044 AU from the Sun, how fast is Jupiter moving? Give your answer in cm/s.
4. Compare the speeds of an automobile, a jet plane, an Earth satellite, Earth in its orbit around the Sun, and a pulse of light. Do this by comparing the relative distance each travels in the same amount of time.
   (a) How far does a commercial jetliner (speed: 650 mph = 1046 km/h) go in 35 milliseconds?
   (b) How far does an Earth satellite (speed: 17,000 mph $\approx$ 27,350 km/h) go in 35 milliseconds?
   (c) How far does Earth travel in its orbit around the Sun (speed: 30 km/s) in 35 milliseconds?
   (d) How far does a light pulse go in a vacuum (speed: 3×10^8 m/s) in 35 milliseconds? This distance is roughly how many times the distance from Boston to San Francisco (5000 km)?
5. At 9:00PM PDT on August 24, 1989, the planetary probe *Voyager II* passed by the planet Neptune. Images of the planet were coded and transmitted to Earth by microwave relay.

   It took 4 hours and 6 minutes for this microwave signal to travel from Neptune to Earth. Microwaves (electromagnetic radiation, like light, but of a frequency lower than that of visible light), when propagating through interplanetary space, move at the "standard" light speed of one meter of distance in one meter of light-travel time (1 m/lm, or 299,792,458 m/s). In the following, neglect any relative motion among Earth, Neptune, and *Voyager II*.
   (a) Calculate the distance between Earth and Neptune at fly-by in units of light-minutes, light-seconds, light-years, meters, and kilometers.
   (b) Calculate the time the microwave signal takes to reach Earth in units of minutes, seconds, and years.