ASTR 1040 RECITATION 2

9/5/2023

KIRK LONG | CU BOULDER

LOGISTICS

- Observatory Monday, 9/11 at 8:30 PM
  - Assignment + details on Canvas page
  - Worth the same as a homework grade
- Problem set 1 due Thursday 9/7
- AHR office hours: Tuesdays 4-6

REVIEW FROM CLASS

What are the four fundamental forces? At which scales does each dominate? What is most important to our class?

Warm-up problem:

Electromagnetism and gravity are the two forces you are most familiar with in ever day life. Coulomb's law tells us the force acting on two charged particles, and it looks a lot like Newton's law of gravitation:

$$|F_C| = K\frac{|q_1 q_2|}{r^2} \text{ where } K \approx 9 \times 10^9\ \mathrm{Nm^2C^{-2}}$$

Compare the differences between Coulomb's law and Newton's law of gravitation. Pretend you rubbed your feet extremely vigorously on the carpet, such that you built up your mass (in kg) as static charge (in C). Also pretend that the Earth's core is somehow given a net charge – how much would this charge need to be to provide the same pull on you as gravity does? Google around to see if you can find any naturally occurring process capable of producing this magnitude of charge.

Compare now a proton and electron in the Earth's upper atmosphere, separated by a distance of 1m. What is the magnitude of the acceleration of the electron towards the proton? Towards the Earth? Which force dominates? Do the same analysis for the proton.

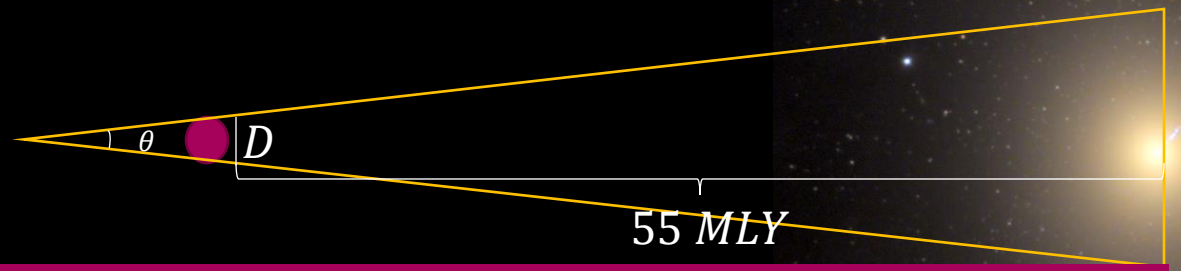
THE SUN AS A GIANT BALL OF GAS

When one kilogram of kerosene (gas) is burned, the chemical reaction releases an enormous ~46 million Joules of energy. As discussed in class, a long time ago prominent scientists once thought that the Sun might be powered by exothermic reactions such as this, and they were perplexed by their calculations, which we will now repeat:

1. Using the known luminosity of the Sun, if we assume it is powered by burning kerosene how many kilograms of fuel must be burned per second?
2. How long would you expect the Sun to live with the reaction rate you calculated in part 1?

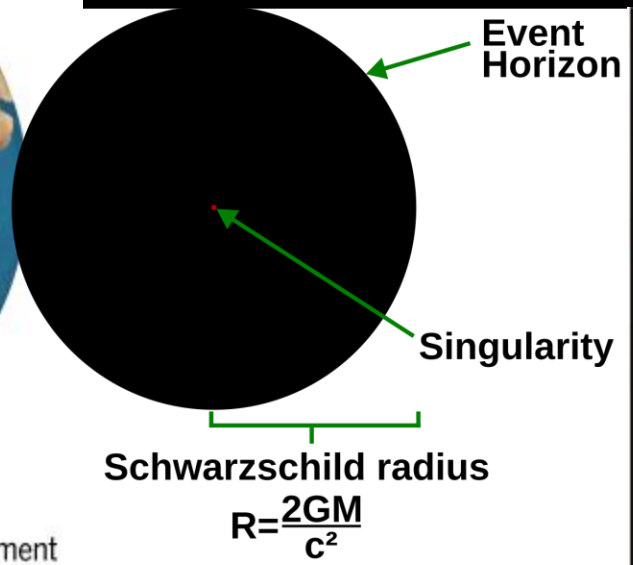
Images: EHT, Pedrotti, NASA/Hubble, Wikipedia Commons

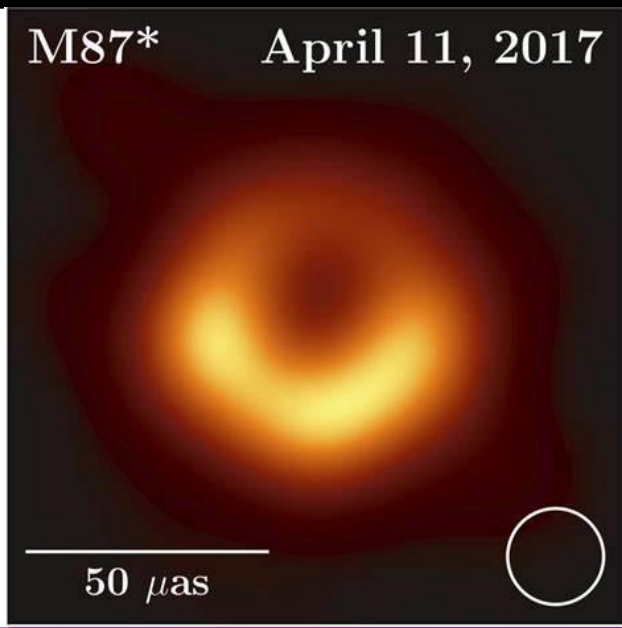
$$\theta_{min} \approx 1.22\frac{\lambda}{D} \approx \frac{true\ size}{distance}$$



1. The EHT observes with a maximum frequency of 450 GHz. Assuming the array spans roughly the diameter of Earth, what is best possible angular resolution of the EHT?
2. The black hole at the heart of M87 has a mass of roughly 5 billion solar masses. Assuming a distance of 55 million light years, what is the angular size of the black hole? Compare this to your answer to part 1.

1. South Pole Telescope **2.** Atacama Large Millimeter/submillimeter Array and Atacama Pathfinder Experiment (Chile) **3.** Large Millimeter Telescope (Mexico) **4.** Submillimeter Telescope (Arizona) **5.** James Clerk Maxwell Telescope and Submillimeter Array (Hawaii) **6.** IRAM 30-meter (Spain)





HOMEWORK QUESTIONS

Look over the homework and ask questions! Ask early and often ☺