

1. A black hole is in the center of our galaxy, and its mass is about 3 million times the mass of the sun.
  - a. (5 pts.) What is the evidence for the black hole in the center of our galaxy?
  - b. (4 pts.) How big is the Schwarzschild radius of that black hole? (Read about black holes in section 18.3 of the textbook.) (1 pt.) Find something in the solar system that is comparable in size to the Schwarzschild radius of the black hole in the center of our galaxy.
2. The temperature of the radiation was 3000K during recombination, and it is 2.728K today. The distance to the Coma cluster of galaxies is 100 Mpc.
  - a. (5 pts.) At the time of recombination, what was the distance between what was to become the Coma cluster and what was to become you?
  - b. (5 pts.) At the time of recombination, what elements were present?
3. The temperature of the cosmic background radiation is not perfectly isotropic.
  - a. (5 pts.) Because we are moving with respect to the Big Bang, the temperature is hottest in a certain direction in the sky and coolest in the opposite direction. The temperature in the hottest direction is hotter by 0.004 K than the average. Find our speed with respect to the Big Bang. (You must show your calculation.) Hint: Wien's Law connects the temperature and the wavelength of the peak of the radiation, and Doppler's effect relates wavelength and speed.