

Ph6820 Homework 4. Due on April 14

1. Fun physics with mean molecular/atomic weight ( $\mu$ ).

Why does the pitch of your voice change if you inhale helium? Assume the size of your vocal cords stay the same (this sets the wavelength of the sound waves). How does the pitch change when you go from a Nitrogen/Oxygen air to pure Helium, i.e. what is the ratio of sound speeds in a normal and Helium atmosphere, and what is the resulting ratio in frequencies?

Would a pure helium balloon float in the atmosphere of Jupiter? The atmosphere of Jupiter is 90% molecular Hydrogen and 10% Helium (by number, not weight). Calculate the net force on the balloon (you will have to look up the mass and radius of Jupiter) as a function of the surrounding atmospheric pressure and temperature. Assume the temperature in the balloon is the same as that in the surrounding atmosphere. This is not hard, you just need a "Eureka!!" moment.

2. Determine the equation for the luminosity time evolution of a main sequence star. The equation should be in terms of the initial luminosity and  $\mu$  at  $t=0$ , the mass of the star, and the energy generation per gram of gas. First calculate the rate at which Hydrogen is converted into Helium and from this get  $dX/dt$  (assume the star is just Helium and Hydrogen). From this measure the time variation of  $\mu$ . Then use the variation of  $\mu$  with time to get the change in luminosity.

3. What mass infall rate is needed to sustain constant Deuterium burning in the center of a protostar? Assume a standard abundance and use a protostar mass of  $0.5 M_{\text{sun}}$  and a radius of  $2 R_{\text{sun}}$ . Also assume the protostar is convective so that Deuterium landing on the surface of the star is transported to the center of the star.