

Problem Set 6  
(due December 4)

1. An average dwarf nova has a mass transfer rate of  $5 \times 10^{-10} M_{\odot} \text{ yr}^{-1}$  onto the surface of a white dwarf during an outburst that lasts 10 days. Estimate the luminosity (in terms of  $L_{\odot}$ ) and total energy released during the outburst. Assume that the white dwarf has  $M = 0.85 M_{\odot}$  and  $R = 0.0095 R_{\odot}$ .
2. Consider a  $10^{-4} M_{\odot}$  layer of hydrogen on the surface of a white dwarf. If this layer were completely fused into helium, how long would the resulting nova last (assume a luminosity equal to the Eddington luminosity)? What can you infer about the amount of hydrogen that actually undergoes fusion during a nova outburst?
3. Consider the dense core of a giant molecular cloud composed of molecular hydrogen with a density of  $10^{10} \text{ m}^{-3}$  and at a temperature of 10 K.
  - (a) Calculate the Jeans length,  $R_J$ , for this core.
  - (b) By using the ideal gas law, calculate  $|dP/dr| \approx |\Delta P/\Delta r| \sim P_c/R_J$  at the beginning of the collapse of this core, where  $P_c$  is an approximate value for the central pressure of the cloud. Assume that  $P = 0$  at the edge of the molecular cloud.
  - (c) Show that, given the accuracy of these crude estimates,  $|dP/dr|$  is much smaller than  $GM(r)\rho/r^2$ . What does this say about the core's dynamics?
  - (d) Show that as long as the collapse remains isothermal, the contribution of  $|dP/dr|$  continues to decrease relative to  $GM(r)\rho/r^2$ , supporting the assumption that this term can be neglected once free-fall collapse begins.