Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are large molecules that are common in the interstellar medium. They consist of linked benzene rings, and can have a very wide range of sizes. The smallest one (naphthalene, consisting of two linked rings) has an atomic weight of 128, while the largest PAHs can have masses of many thousands of amu and are akin to small dust grains. Our goal is to determine whether PAHs should be thought of as a fluid (like hydrogen atoms) or not (like larger dust grains). We will consider a neutral PAH of atomic weight A and cross-sectional area σ in a region of neutral hydrogen of density n and temperature T.

1. Compute the mean thermal velocities $v_{\rm PAH}$ and $v_{\rm H}$ of the PAH and of the hydrogen atoms. By what factor do they differ?

2. Suppose the PAH initially moves through the hydrogen at a velocity $v_{\rm init}$ such that $v_{\rm PAH} \ll v_{\rm init} \ll v_{\rm H}$. Roughly estimate the timescale required for the PAH's direction of motion to be randomised. You may assume that all collisions are elastic.

3. Suppose that $v_{\rm init} = 5$ km s^{-1}, $\sigma = 2 \times 10^{-17} A$ cm^{-2}, and the PAH is moving through a region of atomic hydrogen with $n = 0.1$ cm^{-3} and $T = 8000$ K. Estimate $t_{\rm iso}$ numerically as a function of A.

4. Based on this finding, should we think of PAHs as a fluid? For what range of masses A?