Astrophysics handbook

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1 Energy transport in stellar interiors

This section contains my notes while studying the fifth chapter in the "Theoretical Astrophysics" lecture notes by Paola Marigo.

Energy transport phenomena in stellar interiors are classified into:

1. those which involve stochastic thermal motion of the particles: this is *heat conduction* if it involves the motion of gas and dust particles, and *radiative diffusion* if it involves the motion of photons;

2. those which involve bulk motion of particles: this is called *convection*.

The local form of the first law of thermodynamics can be written in terms of the density: we know that the expression for infinitesimal work is $\delta W = P \delta V$, but the volume is given by $V = m/\rho$. So, $\delta V = \delta(m/\rho) = -m/\rho^2 \times \delta \rho$. So we can express the First Law as:

$$\delta U = \delta Q - \delta W = \delta Q + \frac{Pm}{\rho^2} \delta \rho \tag{1}$$

$$\delta u = \delta q + \frac{P}{\rho^2} \delta \rho \, , \tag{2}$$

where we introduced the internal energy per unit mass $u = U/m$ and the heat per unit mass $q = Q/m$.