Summary of my calculation

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May 23, 2018

1 The equation of energy

Typically, we obtain the equation of energy following

$$\frac{\partial}{\partial t}\left(\frac{1}{2}\rho v^2 + \rho\epsilon\right) + \mathrm{div}\left[\rho\boldsymbol{v}\left(\frac{1}{2}v^2 + w\right)\right] = 0. \tag{1}$$

We also include the effect of radiation. Therefore, we have to add new term following

$$F(r) = -\frac{16\sigma T^3}{3\alpha_R}\frac{\partial T}{\partial r} \tag{2}$$

Where α_R is defined below

$$\frac{1}{\alpha_R} \equiv \frac{\int_0^\infty (\alpha_\nu + \sigma_\nu)^{-1}\frac{\partial B_\nu}{\partial T}d\nu}{\int_0^\infty \frac{\partial B_\nu}{\partial T}d\nu}, \tag{3}$$

where α_ν, σ_ν, B_ν are absorption coefficient, scattering coefficient and planck function. We rewrite (1) from cartesian coordinates to cylindrical coordinates

$$\frac{\partial}{\partial t}\left(\frac{1}{2}\rho v^2 + \rho\epsilon\right) + \frac{1}{r}\left[\frac{\partial}{\partial r}\left(r\rho v_r\left(\frac{1}{2}v^2 + w\right)\right) + \frac{\partial}{\partial\theta}()\right] = 0. \tag{4}$$