RADIATION ASTROPHYSICS I

Problem Set 4
Due: Wed. Oct. 19th

1. The apparent monochromatic luminosity of an unresolved source is given by the volume integral:

\[ L_\nu = \int 4\pi j_\nu \beta(\hat{k}) dV, \]

where \( \beta(\hat{k}) \) is the probability for escape along direction \( \hat{k} \) towards the observer. In the limit of large velocity gradient (LVG), this escape probability is given by

\[ \beta(\hat{k}) = \frac{1 - e^{-\tau_\nu}}{\tau_\nu}, \]

where

\[ \tau_\nu = \frac{\chi c}{|du_s/ds|\nu_0}. \]

Use these expressions to derive Shu’s equations (9.52) and (9.56) for the apparent luminosity of a rapidly-moving, spherically-symmetric outflow in the optically-thin and optically-thick limits.

Hint: In the LVG limit, we may use the approximation

\[ j_\nu = \frac{n_2 A_{21} h\nu_0}{4\pi} \delta(\nu - \nu_0[1 + u_s/c]). \]

2. Use Shu’s equations (9.52) and (9.56) to derive the line profiles he obtains for both the freely-expanding SN remnant and the steady wind coasting at constant speed, in both the optically-thin and the optically-thick limits.