Exercise 4

1. A SN with an expansion velocity of $V = 2 \times 10^4$ km s^{-1} at 10 days after explosion propagates through a stellar wind with mass loss rate $\dot{M} = 2 \times 10^{-5}$ M$_\odot$ yr^{-1} and velocity $u_w = 10$ km s^{-1}. The density of the SN ejecta can be described by a $\rho \propto r^{-10}$ power law.

   (a) What is the temperature and density behind the outgoing, circumstellar shock and the reverse shock? *

   (b) Estimate the cooling time scales of these? Note that on p. 123 in the lecture notes there is a typo: Instead of $t_{cool} = 3kT_e/\Lambda$ the correct expression should be $t_{cool} = 3kT_e/n_e\Lambda$. Also note the different expressions for Λ in the two temperature ranges, also given on p. 123. g_{ff} is the Gaunt factor and can be approximated by $g_{ff} \sim 1$.*

   (c) Calculate the total luminosity from the shocks as function of time. *_**

   (d) When does the cool shell between the shocks become transparent to the X-rays at 2 keV? **

2. In the papers below the gamma-ray burst profile of the GRB 060329 and the optical spectrum of the gamma-ray burst are shown for several epochs. What observations are arguing for that this GRB is originating from a massive star? You should mainly have to look at the figures of these papers. *

   Refs:

   Vanderspek, R., et al. 2004, ApJ, 617, 1251

   Hjorth, J., et al. 2003, Nature, 423, 847