ASTRO 330 - Galaxies:
Star Formation and Rotation Curves
Class 6 Exercise: Feb. 10
Due Feb. 20 as Homework 3

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1. **Hα as a Star Formation Rate Indicator:**
   Pretend there are only two kinds of stars in the Universe: G-stars with $M = 1\ M_{\odot}$ and O-stars with $M = 100\ M_{\odot}$. According to the IMF, for every O-star that is formed, 900 G-stars are formed. The O-stars have lifetimes of $t_O = 10$ Myr while the G-stars live for $t_G = 10$ Gyr (note that these values are similar but not identical to the ones you used in HW2).
   Although G-stars do not produce UV photons that can ionize Hα, O-stars do; the resulting Hα luminosity of a single O-star is $L_*(H\alpha) = 10^{35}$ ergs s^{-1}. A galaxy has been forming stars with a constant rate of SFR=50 $M_{\odot}$ yr^{-1} for 2 Gyr.

   a) [**8 pts**] What is the Hα luminosity you observe from the galaxy, assuming none is absorbed by dust? Show all your work.

   b) [**2 pts**] Now assume that the galaxy formed stars with a constant rate of SFR=50 $M_{\odot}$ yr^{-1} for 2 Gyr, but in the last 5 Myr this has increased to SFR=500 $M_{\odot}$ yr^{-1}. Would the observed Hα luminosity be higher or lower than your answer in part (a) ? Why?

2. **Galaxy Rotation Curves**

For an object of mass m in uniform circular rotation, the centripetal force equals the gravitational force:

$$m\frac{V_c^2}{r} = \frac{GM(r)m}{r^2}$$

where V_c is the circular velocity and $M(r)$ is the mass enclosed by radius r.

a) **[4 pts]** Suppose that a galaxy has a spherical dark matter density distribution with a constant density $\rho(r) = C$. Solve for the dependence of V_c on r and sketch the rotation curve.

b) **[6 pts]** Now suppose that the dark matter density distribution scales as $\rho(r) \propto r^N$. What value of N is required for the rotation curve of the galaxy to be flat? Show how you arrive at this answer. To do this problem correctly you'll need to integrate to get $M(r)$. (Hint: think of the mass in a thin spherical shell.)