Problem Set - 2

Compact Binary Evolution, Rates and Population Modelling

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Problem 1:

Mass transfer: Assume that the more massive component of the binary, m_1 undergoes mass transfer ($dm_1/dt < 0$), where some fraction of the mass (β) may be lost due to various mechanisms like stellar winds.

1. Conservative case: For $\beta = 0$, calculate whether mass transfer in a binary shrinks the orbit or expands it as a function of mass ratio.

2. Non-conservative case: Evaluate the change in the orbital separation by considering some non-zero values of β. Plot the change as a function of different beta values.

Problem 2:

Simulating a Population of Binaries

1. The mass function of stars was first posited by Edwin Salpeter in 1955. While there are many updated models for the mass function, we use the Salpeter mass function for illustration purposes. The mass function $\xi(m)$ is given by
$$\xi(m) \propto m^{-2.35}.$$
Draw samples from this mass function for the primary mass in the binary. Assume that the minmum mass of stars under consideration is $20 M_\odot$ and maximum mass is $150 M_\odot$.

2. Assume that the distribution of mass ratio $q = m_2/m_1$ (ie. smaller mass divided by larger mass) is uniform. That is, $p(q) =$ constant, with limits 0.25 to 1.

3. Calculate the remnant mass by assuming
$$M_{\text{remnant}} = M_{\text{initial}}^{\alpha};\ \alpha = 0.75.$$
This power-law prescription is rather heuristic, and you can try to play around by changing the power law exponent.

4. Opik's law models the distribution of initial separation a as $\frac{dP}{da} \propto 1/a$ ie. $\frac{dP}{d(\log a)} \propto 1$. Hence, this corresponds to sampling a from a logUniform distribution. We will use the upper and lower limits as $10 R_\odot$ and $10^5 R_\odot$.

5. Put all the above together to calculate the time delay distribution. Use functions written in Problem Set 1.