Homework 5

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The (fairly large) Table is attached containing all of my test results. I ”simulatedä total of 52 main sequence binary pairs, varying pair masses for a fixed mass ratio of q = 0.3 and 0.9, and did so for two different ellipticies, e = 0 and e = 0.7. In each case, star 1 is the more massive of the two. For q = 0.9, $1.0 M_\odot \leq M_1 \leq 30.0\ M_\odot$, corresponding to a companion mass range of 0.9 $M_\odot$ to 27.0 $M_\odot$. The q = 0.3 cases had the same mass samples, though with an extra couple samples at M_1 = 50 $M_\odot$ and 60 $M_\odot$. This is a companion mass range of $0.3\ M_\odot \leq M_2 \leq 18\ M_\odot$. All other parameters were left at their default, so period was 1000 days and maximum evolution time was 13.7 Gyr.

Given in the table are the end products of each star, both type and mass, the most massive isotope created by each star, and the length of the symbiotic phase, thermal pulse AGB (TP AGB) phase, and the blue straggler phase in Myr. The time length of many of these phases for the stars is marked as zero. This is either because the phase never occurred (most likely) or because the length of time of the phase was very very short before it transitioned to a different phase (the smallest δt possible was 0.1 kyr). This occurred fairly often. The last column gives the formation time of the NS-NS or BH-NS pair (if one formed). I was unable to produce any BH-BH pairs with these parameters.

To answer your questions:

Least massive single stars:

1. CO WD: 0.55 $M_\odot$. Generated from M_1= 1 $M_\odot$, M_2= 0.3 $M_\odot$, and e = 0. Companion remained a low mass main sequence star. (Pair 12)

2. He WD: I only managed to form two He WD's. Both came from M_1= 1 $M_\odot$, occurring at both q but only when e = 0.7. Pairs 25 and 36. The He WD masses were both about 0.42 $M_\odot$.

3. NS: I ended up creating many neutron stars. The least massive came from Pairs 30 and 41. Both had M_1= 8.0 $M_\odot$and e = 0.7. The NS mass was 1.294 $M_\odot$. I made many NS around 1.3 $M_\odot$.

4. BH:

Longest lived phases:

1. Thermal Pulsing AGB: Longest phase was about 2.7 Myr. This occurred in pair 1, with M_1= 1 $M_\odot$, q = 0.9, e = 0. When it did occur, most phases were at or below 1 Myr.

2. Symbiotic: This did not occur too often. Most often when one star was in the RG phase, the other was still main sequence and not a compact companion. In the cases were it did occur, it was short lived. The longest was 0.5 Myr, for Pair 4, with M_1= 3 $M_\odot$, q = 0.9, and e = 0.

3. Blue Straggler: Most often, when this phase did occur, it occurred for too short a time to be recorded. I include two columns in the table, since some pairs had both stars go through a blue straggler phase. The longest lived was for pair 11, where the phase lasted for star 1 for 0.3 Myr and star 2 for 0.7 Myr. This pair had $M_1 = 30\ M_\odot$, q = 0.3, and e = 0.

The **shortest time for a NS pair formation** was from the $M_1 = 50\ M_\odot$ and q = 0.3 stars (Pairs 23 and 47). The higher eccentricity of the two made the process occur faster, with the quickest formation time at 13.5 Myr.

The **heaviest isotope** I made was W188, and it happened a couple times. It occurred at q = 0.3 and 0.9 for $M_1 = 3.0\ M_\odot$. The end stars in each case were a CO WD and a massless remnant.

In general, I found that a higher eccentricity sped up the evolution of the system and more often led to the destruction of the lower mass companion. Changing the mass ratio also had similar effects. The q = 0.3 cases increased the likelihood that the more massive companion will survive. Also, I managed to make one 1.33 $M_\odot$ Oxygen-Neon white dwarf, from pair 14.