Problem Set 8

1 Black Hole Mergers

In the last decade – after many decades of hard work! – physicists have detected gravitational waves from merging stellar mass black holes. These have been quite different from the sources we expected and have raised many questions about stellar mass black holes. Read this article: https://www.quantamagazine.org/colliding-black-holes-tell-new-story-ofstars-20160906/ Summarize the models for the formation of these systems, and weigh the evidence to determine what you think is the most likely option. (There's no right answer, though you can find more recent discussions on the internet if you want to see what has been learned since!)

1. Common-Envelope Evolution (Classic Theory):

- Formation: A pair of massive stars begins in a wide orbit.
- Black Hole Formation: Star A collapses into a black hole while Star B grows, further shrinking the orbit. When Star B exhausts its fuel, it also collapses into a black hole. The two black holes, now close, eventually spiral into each other and merge.
- Key Features: This process involves complex interactions with hydrogen envelopes and gas loss, which draw the stars closer.

2. Chemically Homogeneous Evolution (New Theory):

- Formation: Two massive stars in a tight orbit are "tidally locked". Their rapid spinning stirs the stars, maintaining uniform chemical composition and high internal heat.
- Black Hole Formation: Unlike most stars, which have distinct core and envelope layers, these stars fuse entirely and contract into compact black holes without shedding much material. The black holes are already close, and their merger happens as they spiral closer due to gravitational waves.
- Key Features: This model skips the envelope phase and results in direct black hole formation in a tight orbit.

The Chemically Homogeneous Evolution model seems most plausible for explaining the unexpected large masses of black holes in recent mergers. However, the Common-Envelope Evolution might still account for a broader range of scenarios. Future data could favor one model definitively, or they might work in tandem to explain different types of mergers.

Bibliography