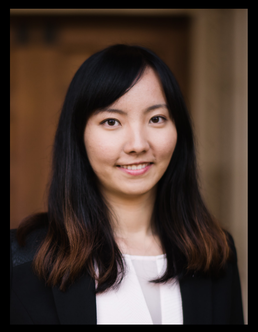
Supernova Kicks in Hierarchical Triple System

Cicero X. Lu[1,2] and Smadar Naoz[1,3] (Lu&Naoz 2019)
1.University of California, Los Angeles 2. Johns Hopkins University
3. Mani L. Bhaumik Institute for Theoretical Physics, UCLA



ABSTRACT

Most massive stars, if not all, are in binary configuration or higher multiples. Recently, it was suggested that binaries are prevalent in the galactic center, and that the total massive binary fraction in the galactic center is comparable to the galactic binary fraction. These massive stars in binaries undergo supernova explosions and end their lives as either black holes or neutron stars. Observations have suggested that neutron stars and perhaps even black holes receive large velocity kicks at birth. Such natal kicks and the sudden mass loss can significantly alter the orbital configuration of the system.

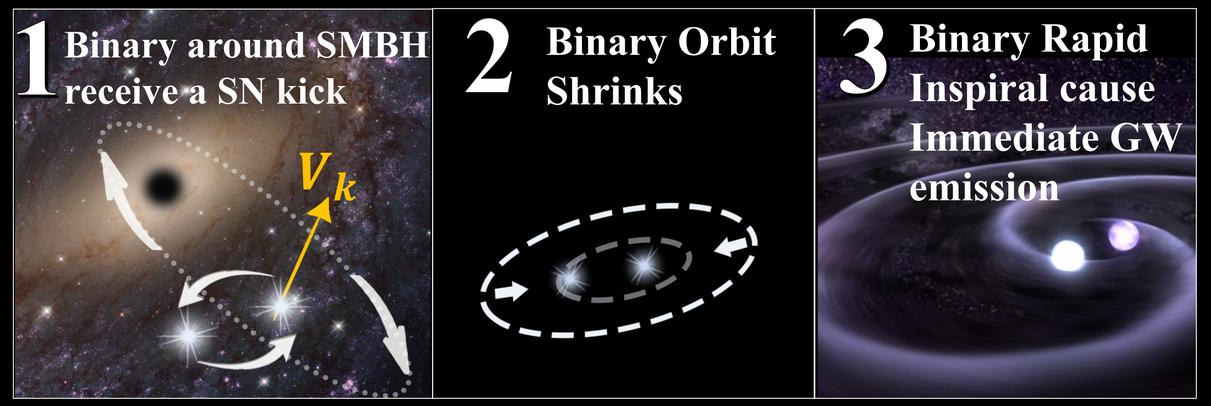
We explore several proof-of-concept applications such as black hole and neutron stars binaries and X-ray binaries with Supermassive Black Hole (SMBH) companions on a wide orbit.

METHODS

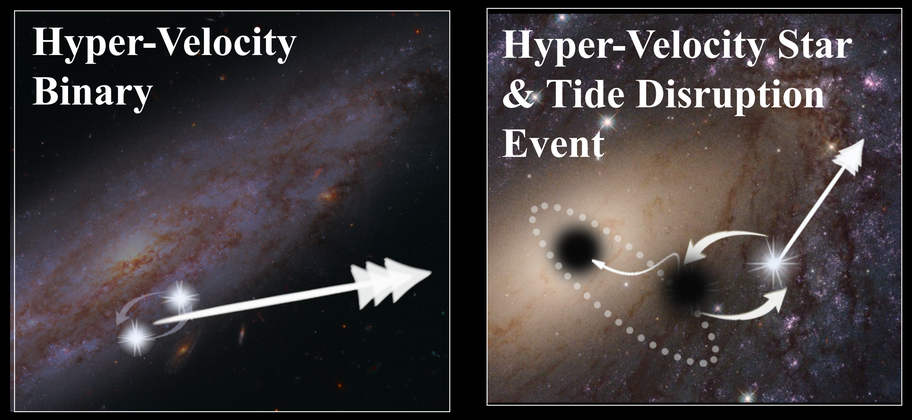
The hierarchical triple system consists of a tight binary and a third body on a much wider orbit. The triple can be reduced into two separate Keplerian orbits.
We choose inner orbit semi-major axis to be uniformly distributed between 5-1000$R_{\odot}$. We choose outer orbit semi-major axis to follow Bahcall-Wolfe distribution (between 100 AU – 0.1 pc) and Extreme-cusp distribution.

RESULTS

Gravitational Wave Emission Scenario:



Other Possibilities:



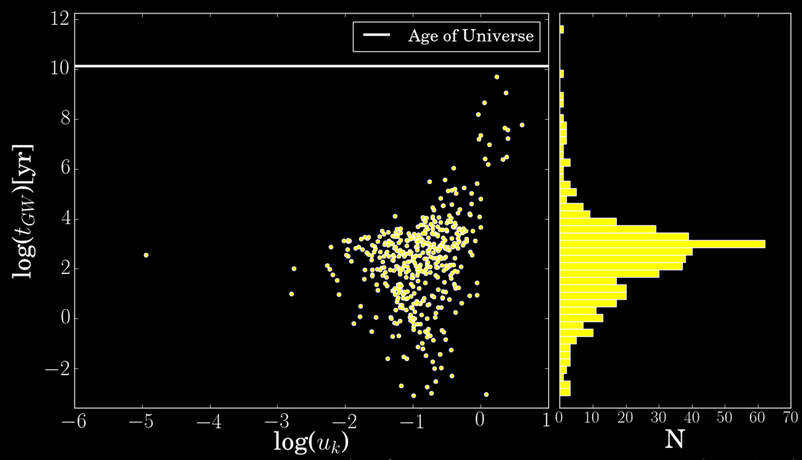


Figure. NS-NS GW timescale after two SNs in systems around SMBH third companion with $a_1 = 5R_{\odot}$ and a_2 from Monte Carlo, Bahcall-Wolfe distribution.
Left Panel: We show the GW timescale as a function of the dimensionless kick velocity, *uk*. In the right Panel we show the histogram of the GW timescales.

IMPLICATIONS

1. Simultaneous and precursors electromagnetic signatures for LIGO compact object merger event. (For NS-BH, BH-BH and NS-NS)
2. Electromagnetic precursors for LISA events.
3. Triple configuration remains bound when the tertiary is more massive. This trend has significant implications on the formation of Low-Mass X-ray Binaries.

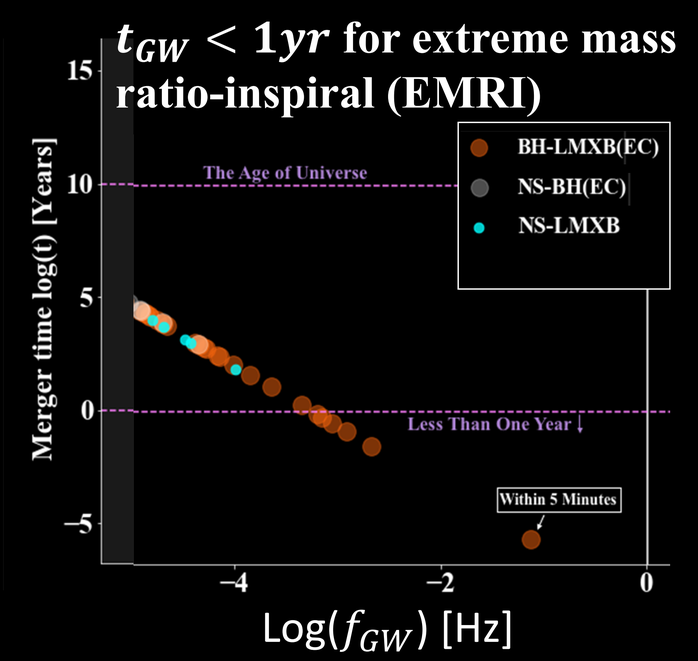


Figure: EMRI GW merger time after SN versus GW emission characteristic frequency. We consider all systems in our proof-of-concept Monte-Carlo that crossed the SMBH Roche limit .

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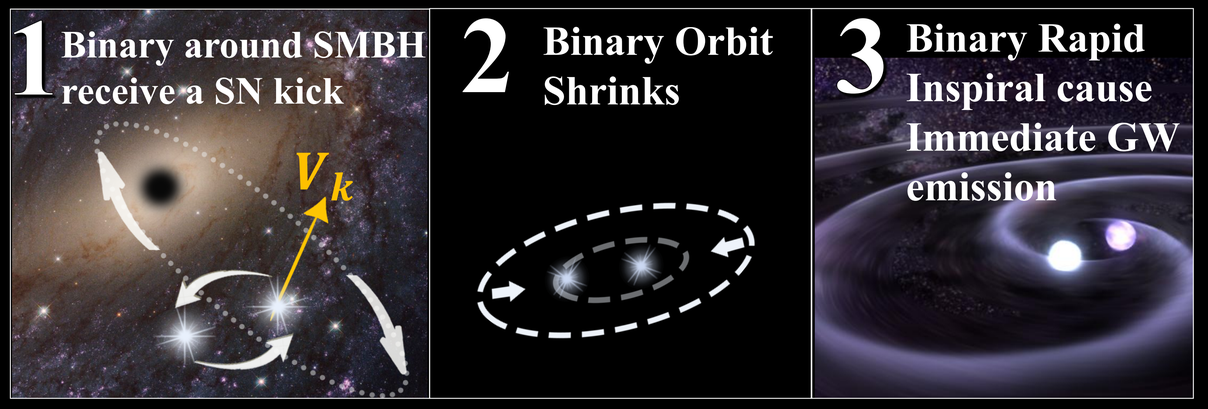

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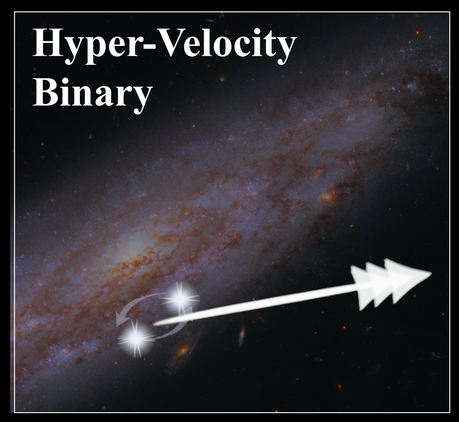

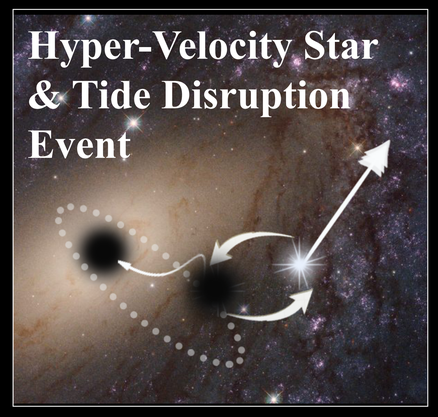

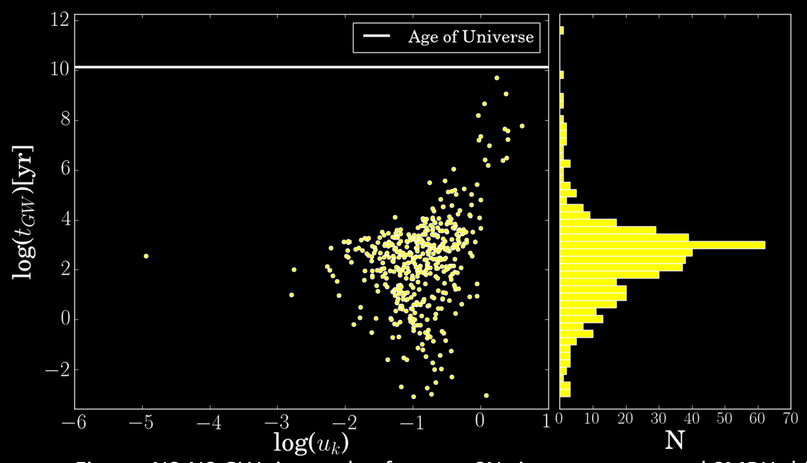

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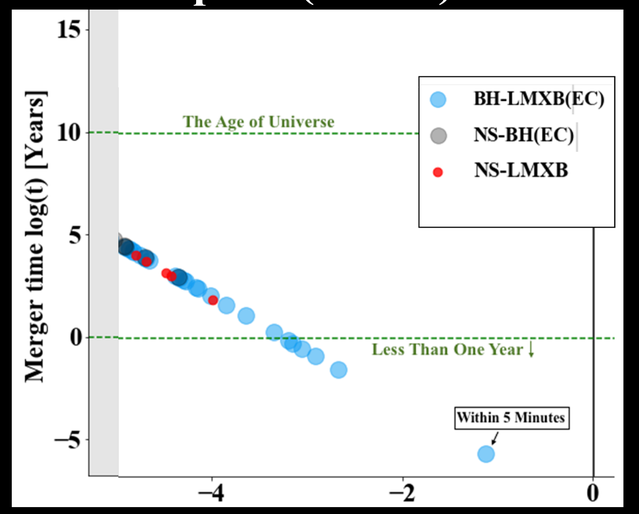
$t_{GW} < 1yr$ for extreme mass ratio-inspiral (EMRI)



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