W57a The redshift-evolving eccentricity distribution of gravitational wave sources

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The formation of merging binary black holes (BBHs) form remains a key unresolved issue in astrophysics, despite nearly 100 detections by the LIGO-Virgo-KAGRA collaboration. Detectable eccentricity offers one of the most promising ways to distinguish different formation channels. However, detecting a sufficient number of eccentric mergers to reliably carry out such a task is expected to be feasible only with third-generation GW detectors, such as the Einstein Telescope or Cosmic Explorer. As these instruments will detect BBH mergers up to redshift z$\sim$6, it is critical to understand how the eccentricity distribution evolves with redshift.

We predict the evolution of eccentricity distributions over redshift for merging BBHs from two key channels: the globular cluster (GC) channel and the hierarchical triple channel, where three-body dynamics induce high eccentricities in the inner binary. Our population synthesis method shows that mergers from the GC channel dominate in the local universe (z$\sim$0) by an order of magnitude, in broad agreement with previous studies. However, if we focus only on mergers that have detectable eccentricity with third generation detectors (e $\gtrsim$ 10^{-4} - 10^{-3} at 10 Hz), this picture considerably changes: at z$\sim$ 0, 40% of eccentric mergers arise from hierarchical triples, and this fraction rises to 70% at z$\sim$2-3. Therefore, high-redshift eccentric mergers may be dominated by field triples, challenging the view that such mergers primarily occur in dense environments.