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Postmerger: a new and dominant contribution to the gravitational-wave background from binary neutron stars

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The stochastic gravitational-wave background (SGWB) generated by the inspiral and merger of binary neutron stars is traditionally modelled assuming that the inspiral is promptly followed by the collapse of the merger remnant to a rotating black hole. While this is reasonable for the most massive binaries, it is not what is expected in general, where a remnant is produced and may survive for up to hundreds of milliseconds and radiate an amount of energy that is significantly larger than that lost during the whole inspiral. To account for this additional contribution to the SGWB, we consider a waveform model that includes both the inspiral and the postmerger emission. We show for the first time that for a large set of parameterized equations of state compatible with observational constraints, there is typically five times more power spectral density in the SGWB from the postmerger emission than from the inspiral one, leading to a normalized GW energy density ΩGW ~ 10-10-10-9. This power is predominantly located in the 1-2 kHz frequency range and hence distinct from that associated with the inspiral only. We discuss the significantly enhanced detectability of the SGWB with special attention to third-generation detectors, such as the Einstein Telescope and Cosmic Explorer, and show how it depends on the signal-to-noise ratio of foreground binaries and on the metastable remnant survival time. Interestingly, even a non-detection of the high-frequency part of the SGWB could provide valuable constraints on the remnant lifetime, offering novel insights into the postmerger dynamics and into the equation of state of nuclear matter.

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