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Constraining the mass of neutron stars in compact binaries with multi-messenger observations

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Black widow systems are a class of rotation-powered pulsar binaries, consisting of a millisecond pulsar irradiating and ablating a sub-stellar mass companion. They are believed to be at the end of their recycling process, by which the neutron star has spun up and acquired considerable masses. Observations suggest that these systems potentially hold the most massive neutron stars in our Universe, with several systems reported to have neutron star greater than 2 solar masses based on optical photometric and spectroscopic observations. Nevertheless, the existing methods to determine the neutron stars'masses bear uncertainty due to complicated model systematics. In this research, we focused on the compact black-widow-like systems with orbital period less than 1 hour and showed that these systems are potential gravitational wave sources detectable by LISA. By combining the binary mass function measured via optical observations with the complimentary mass function derived from the gravitational wave observations, we proposed a novel multi-messenger method to constrain the mass of the neutron stars in such binaries. We showed that our method has the potential to test the existing equation-of-state (EOS) models and to help us to understand the composition of the ultra-dense materials.

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