Tidal deformability of crystallized white dwarfs in full general relativity

L. Perot, N. Chamel

Universit Libre de Bruxelles, Belgium

Space-based gravitational-wave detectors offer new prospects for probing the interior of white dwarfs in binary systems through the imprints of tidal effects on the gravitational-wave signal. Some of the binaries that will be observed could have evolved for long enough for the white dwarfs to be at least partially crystallized. The apsidal motion constant k_2 (also called the second gravitoelectric Love number) of a cold crystallized white dwarf was computed in full general relativity considering different compositions. The elasticity of the crystallized core was found to systematically reduce the tidal deformability, especially for low-mass stars. Fully relativistic results were compared to those obtained in Newtonian gravity. It was shown that the relativistic correction to the observable tidal deformability k_2R^5 (where R is the stellar radius) is negligible for low-mass white dwarfs but becomes increasingly important for more massive white dwarfs. When approaching the maximum mass, the application of Newtonian theory instead of general relativity leads to dramatic errors. The case of eccentric binaries, for which the precession of the periastron causes a frequency splitting of the gravitational-wave signal depending on the apsidal motion constants of the two stars, was investigated. Future measurements of the precession rate by the Laser Interferometer Space Antenna, which is planned to be in operation within the next decade, could potentially provide estimates of the individual masses. It was found that the errors incurred by the neglect of the elasticity of the crystallized core could be very large, especially for low-mass white dwarfs. Gravitational-wave observations could thus provide a new way to study the crystallization of white dwarfs.