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Quasi-radial instability of differentially rotating relativistic stars

The stability against gravitational collapse of the remnant left by a merger of binary neutron stars is of great interest in gravitational-wave astronomy. This property can be explored with simulations in full general relativity, which are often computational extremely demanding. A well-established result in this landscape is that the rotation of the remnant is a crucial factor in determining its stability. In the case of uniform rotation, the turning-point method by Friedman, Ipser and Sorkin (1988) provides a shortcut to study physical properties regarding the stability of neutron stars in a more computational-affordable way. This method is based on the study of the *turning points*, which are particular equilibrium models that satisfy a specific condition and that can be found without performing full simulations. The turning-point method detects the onset of secular instability, which is, in general, close to the dynamical instability to collapse. Here, we applied the turning-point method to differentially rotating neutron stars, obtaining an estimation of the location of the instability region in the parameter space, for different equations of state and rotation laws. To validate this approach we performed three-dimensional simulations of select models to find the onset of dynamical instability. Furthermore, we report on universal relations among some of the physical properties of interest along the sequence of turning-point models.

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