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On the maximum mass and stability of differentially rotating neutrons stars

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The dynamical stability of differentially rotating neutron stars
is of paramount importance in understanding the fate of the post-merger remnant of binary neutron stars mergers and the formation of black holes during core collapse supernovae. We study systematically
the dynamical stability of differentially rotating neutron stars for a broad range of masses, rotation rates and degrees of differential rotation. We pay particular attention to quasi-toroidal configurations that are outside the parameter space region explored in previous works. We estimate the limits of the region of stability against quasi-radial perturbations by performing an extensive set of numerical simulations. We find that some of the stability criteria proposed in the past are not sufficient nor necessary to determine stability if differential rotation is present and propose a new more general criterion. We show that massive configurations, up to 2.5 times the maximum mass of a non-rotating neutron stars could be temporary stabilised by differential rotation. They are important source of gravitational waves.

Primary author: Prof. ROSINSKA, Dorota (OA, University of Warsaw)

Co-authors: CERDA-DURAN, Pablo (University of Valencia); SZEWCZYK, Pawel (OA, University of Warsaw)

Presenter: Prof. ROSINSKA, Dorota (OA, University of Warsaw)

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