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Universal Relations for the Increase in the Mass and Radius of a Rotating Neutron Star

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Rotation causes an increase in a neutron star's mass and equatorial radius. The mass and radius depend sensitively on the unknown equation of state (EOS) of cold, dense matter. However, the increases in mass and radius due to rotation are almost independent of the EOS. The EOS independence leads to the idea of neutron star universality. In our paper, we computed sequences of rotating neutron stars with constant central density. We use a collection of randomly generated EOSs to construct simple correction factors to the mass and radius computed from the equations of hydrostatic equilibrium for nonrotating neutron stars. The correction factors depend only on the nonrotating star's mass and radius and are almost independent of the EOS. This makes it computationally inexpensive to include observations of rotating neutron stars in EOS inference codes. We also construct a mapping from the measured mass and radius of a rotating neutron star to a corresponding nonrotating star. The mapping makes it possible to construct a zero-spin mass–radius curve if the masses and radii of many neutron stars with different spins are measured. We showed that the changes in polar and equatorial radii are symmetric, in that the polar radius shrinks at the same rate in which the equatorial radius grows. This symmetry is related to the observation that the equatorial compactness (the ratio of mass to radius) is almost constant on one of the constant-density sequences.

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