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Four-hair relations for differentially rotating neutron stars in the weak-field limit JOSEPH BRETZ, Montana State University, KENT YAGI, Princeton University, NICOLAS YUNES, Montana State University — The opportunity to study physics at supra-nuclear densities through x-ray observations of neutron stars has led to in-depth investigations of certain approximately universal relations that can remove degeneracies in pulse profile models. One such set of relations, the three-hair relations, were found to hold in neutron stars that rotate rigidly, but neutron stars can also rotate differentially, as is the case for proto-neutron stars and hypermassive transient remnants of binary mergers. We extend the three-hair relations to differentially rotating stars for the first time with a generic rotation law using two approximations: a weak-field scheme (an expansion in powers of the neutron star compactness) and a perturbative differential rotation scheme (an expansion about rigid rotation). The resulting relations include the fourth moment, hence deemed the four-hair relations for differentially rotating neutron stars, and are found to be approximately independent of the equation of state to a higher degree than the three-hair relations for uniformly rotating stars. Our results can be instrumental in the development of four-hair relations for rapidly differentially rotating stars in full general relativity using numerical simulations.

Joseph Bretz
Montana State University

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