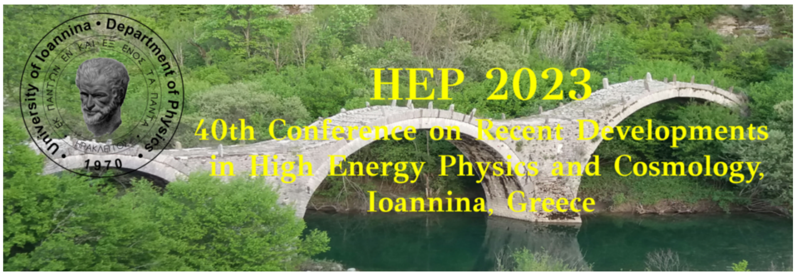

Contribution ID: **66** Type: **not specified**

Universal Relations for rapidly rotating neutron stars using supervized machine learning techniques

Friday 7 April 2023 18:40 (20 minutes)

Neutron stars are some of the most fascinating stellar objects in the universe, offering unique opportunities to study fundamental physics at supra-nuclear densities. However, their internal structure remains poorly known due to the uncertainties in the equation of state (EoS). In recent years, a lot of work has revealed the existence of universal relations between various observable quantities, such as the star's moment of inertia, the quadrupole moment, etc. These relations are insensitive to the EoS and offer a promising way to infer the fundamental properties of dense matter. At the same time, the fields of multimessenger astronomy and machine learning have advanced significantly, enabling us to discover and validate these relations in a new way. As such, there has been a confluence of research into their combination, and the field is growing. In this work, we developed universal relations for rapidly rotating neutron stars by using supervised machine learning methods such as Linear Regression and Cross Validation, thus proposing a new way of discovering and validating such relations. More specifically, we investigated EoS-insensitive relations for the star's normalized moment of inertia $\bar{I}$, the star's reduced quadrupole deformation $\bar{Q}$, and the star's spin octupole moment $\bar{S}_3$, to name a few. The comprehensive analysis is performed for tabulated hadronic, hyperonic, and hybrid EoS-ensembles that obey the multimessenger constraints and cover a wide range of stiffnesses. The relations suggested could provide an accurate tool to constrain the EoS of the dense nuclear matter when measurements of the relevant observable quantities become available.

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Session Classification: Parallel (Theory)