IWARA
From Quarks to Cosmos

9th International Workshop on Astronomy and Relativistic Astrophysics

Posters Spotlight Plenary Talks

6-12, September 2020

Study of Ultracompact Stars in General Relativity

The present work's aim is to investigate the so-called ultracompact stars. This analysis is performed taking into consideration influences both in the metric and in the matter structure, through deformed geometries, anisotropies in the energy-momentum tensor, and adequate equations of state. These characteristics are required since ultracompact stars almost certainly will exhibit, besides the undeniable very high density, intense magnetic fields and high rotation. To this extent, the stars are studied using non-spherical models. Accordingly, through the employment of modified TOV equations and selected equations of state, significant results are achieved. Interesting prospects – like the comparison to models which possess magnetic fields or rotation in its own structure – can begin to be outlined.

Luan Costa da Costa

luan.cost@hotmail.com

IF-UFRGS, Brazil

- Co-authors:

Dimiter Hadjimichef

Kepler de Souza Oliveira Filho

UFRGS
UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

How can we describe an ultracompact star? What are the effects of this description on the measurable physical quantities of stars?

- We consider that very intense magnetic fields, rotations, and very high densities can be modeled by anisotropic EoSs or deformed geometries.
- We then use two formalisms that are based on modifying the TOV equations in the metric structure that produce them:
  - The first modification that we have studied is the one proposed by Zubairi et al. [1]. In this case, we assume a perfect fluid, but a static and deformed star.
  - Alternatively, in a second modification, which is based in the work of Raposo et al. [2], for the treatment of the so-called “C stars”, we introduce an anisotropy in the fluid.

- Motivated by possible evidences from strange stars, and also in theoretical investigation of recent works, we have used heretofore only the Bag Model EoS. Eventually, we intend to use other types of EoS as well, not only for strange stars but also for hybrid stars.

- References:

[1] O. Zubairi et al. Non-Spherical Models of Neutron Stars. arXiv:1504.03006 [astro-ph.SR], September 2014.

[2] G. Raposo et al. Anisotropic Stars as Ultracompact Objects in General Relativity. Phys. Rev. D 99, 104072, 2019.

First formalism: deformation

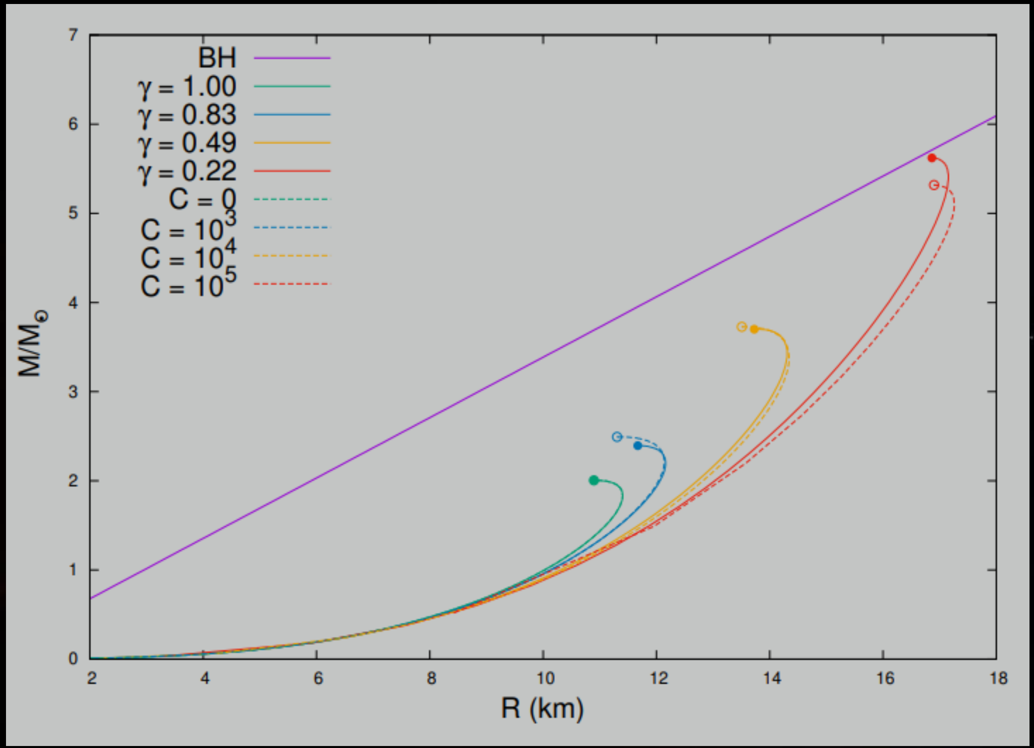
$$\frac{\partial p}{\partial r} = -\frac{(\varepsilon+p)\left[4\pi r^3 p + \frac{1}{2} r\left(1-\left(1-\frac{2m}{r}\right)^\gamma\right)\right]}{r^2\left(1-\frac{2m}{r}\right)^\gamma}$$

$$\frac{\partial m}{\partial r} = 4\pi\gamma\, r^2\varepsilon$$

Second formalism: anisotropy

$$\frac{\partial P_r}{\partial r} = -\frac{(\varepsilon+P_r)\left(4\pi r^3 P_r + m\right)}{r^2\left(1-\frac{2m}{r}\right)\left(\frac{2}{r}Cf(\varepsilon)\sqrt{1-\frac{2m}{r}}+1\right)}$$

$$\frac{\partial m}{\partial r} = 4\pi\, r^2\varepsilon$$



- Figure 1: Mass-radius diagram for sequences of strange stars, varying, separately, the values of γ and C.

Equation of State

$$p(\varepsilon) = \frac{1}{3}(\varepsilon - 4B)$$

- Conclusions:

- It was possible to establish the bases for an investigation that make it possible to obtain masses greater than the currently accepted maximum mass for neutron stars.
- Furthermore, through the use of modified TOV equations and selected EoSs, significant results can be achieved. In this way, comparison with models that have magnetic fields or rotation in their own structure can begin to be outlined.