Rueda Hernández Jorge Armando

Position: *Researcher at ICRANet and Sapienza University of Rome*
Period covered: 2010

I Scientific Work

- *Neutron star physics:* the electrodynamical properties of neutron stars are studied by formulating self-consistently the equations of equilibrium governing neutron star interiors including the nuclear interaction, the gravitational interaction and the electro-weak interaction between particles, all duly expressed in general relativity. The general relativistic equations of equilibrium are integrated numerically to obtain the properties of neutron star cores and neutron star crusts.
- *Nuclear physics:* we study the properties of nuclear matter under extreme conditions of compression through the solution of the relativistic Thomas-Fermi equations of equilibrium. We apply our approach to the construction of neutron star crust and white-dwarf matter equation of state.
- *Critical fields in neutron stars and black holes:* we study the conditions under which critical electromagnetic fields can develop in neutron stars. The subsequent evolution of the electromagnetic fields in the collapse of neutron stars to black holes is also investigated and applied to the physics of extreme astrophysical phenomena like Gamma-Ray-Bursts.

II Conferences and educational activities

II a. Conferences and Other External Scientific Work

- 2nd Galileo-Xu Guantqi Meeting, Ventimiglia (Italy), July 12-18, 2010.
- 11th Italian-Korean Symposium on Relativistic Astrophysics, Seoul (Korea), November 2-4, 2009
- 1st Galileo-Xu Guangqi Meeting, Shanghai (China), October 26-30, 2009
- 12th Marcel Grossmann Meeting On General Relativity, Paris (France), July 12-18, 2009
- 6th Italian-Sino Workshop on Relativistic Astrophysics, Pescara (Italy), June 29-July 1, 2009
- 1st Sobral Meeting, Fortaleza (Brazil), May 26-29, 2009
- 3rd Stueckelberg Workshop on Relativistic Field Theories, Pescara (Italy), July 8 - 18, 2008
- April Meeting of the American Physical Society, St. Louis (Missouri - USA), April 12-15, 2008
- 4th Italian-Sino Workshop on Relativistic Astrophysics, Pescara (Italy), July 20 - 30, 2007
- 10th Italian-Korean Symposium on Relativistic Astrophysics, Pescara (Italy), June 25 - 30, 2007
- 1st Cesare Lattes Meeting on Gamma Ray Bursts, Black Holes and Supernovae, Mangaratiba (Brazil), February 25 - March 3, 2007

II b. Work With Students

- *With Daniela Pugliese (IRAP Ph. D student 3rd-year):* we have formulated the general relativistic equations of equilibrium for a fluid of degenerate neutrons, protons and electrons in beta equilibrium including the nuclear interaction, the gravitational interaction and the electro-weak interaction between particles. Our work generalizes previous results about the general relativistic conditions of equilibrium for multi-component fluids (Klein 1949, Kodama and Yamada 1972, Olson and Bailyn 1975-1976-1978) by including the Coulomb interaction between charged particles and the nuclear interaction between nucleons through the extension to general relativity of the extended Walecka model usually employed for the description of nuclei. We use such a formulation to study the properties of the core-crust phase-separation in neutron stars.
- *With Riccardo Belvedere (IRAP Ph. D student 2nd-year):* We construct neutron star equilibrium configurations by integrating numerically the set of self-consistent ground-state equilibrium equations for neutron stars we have obtained with Daniela Pugliese taking into account quantum statistics,

electro-weak, and strong interactions, within the framework of general relativity. We calculate the mass and the thickness of the outer crust of neutron stars for different core-models obtained for selected parametrizations of the extended Walecka model. Furthermore, we study the influence of the core-model on the nuclear element abundances in the outer crust. The analysis is performed for different equations of state of the outer crust.

- _With Maria Haney (IRAP Ph. D student 2nd -year):_ We study the collapse to a black hole of the neutron star configurations. Such neutron star equilibrium configurations are characterized by possessing an electromagnetic structure. Therefore, we investigate the dynamic evolution of the electromagnetic fields in the collapsing phase.

- _With Kuantay Boshkayev (IRAP Ph. D student 2nd -year):_ In collaboration with Michael Rotondo (Researcher at ICRANet and Sapienza University of Rome) we study the effects of rotation on the properties of the new neutron star equilibrium configurations. In particular, we study the magnetic field created by the rotation of the internal electric field of the configurations. We study the construction of the internal Hartle-Thorne metric for the neutron star configurations we obtain in the static case.

- _With Sheyse Martins de Carvalho (Erasmus Mundus Ph. D student 1st-year):_ We are studying the influence of the temperature on the properties of neutron stars by extending the formulation we did with Daniela Pugliese to the non-degenerate fermion case. On the other hand, we will study the crust matter equation of state through the formulation of a full Thomas-Fermi theory. Such a formulation joins the extended Walecka model for nuclear interaction with the relativistic Thomas-Fermi model proposed by our group to model the Coulomb interaction between the charged nucleus and relativistic surrounding electrons.

II c. Diploma thesis supervision
Sheyse Martins de Carvalho (Erasmus Mundus Ph. D student 1st-year): Ph. D Thesis: "On the electrodynamics of Neutron Stars". We extend the previous results of Daniela Pugliese and Riccardo Belvedere (both IRAP Ph. D-students, 3rd and 2nd year respectively) by including on neutron star configurations the effects of temperature. Furthermore, we construct new neutron star equilibrium configurations including a new equation of state for the crust of the neutron star, which treats self-consistently both the nuclear interaction inside the nucleus and the Coulomb interaction between the nucleus and the surrounding electrons in relativistic regimes.

II e. Work With Postdocs
- _With Michael Rotondo (Researcher at ICRANet and Sapienza University of Rome):_ In collaboration with Kuantay Boshkayev (IRAP Ph. D student 2nd -year) we study the effects of rotation on the properties of the new neutron star equilibrium configurations. In particular, we study the magnetic field created by the rotation of the internal electric field of the configurations. In addition, we study the construction of the corresponding internal Hartle-Thorne metric for the neutron star configurations we obtain in the static case.

2010 List of Publications

Refereed Journals
- **The solution of the Thomas-Fermi equation for neutron star matter in presence of strong magnetic fields**, R. Mohammadi, Jorge A. Rueda, Remo Ruffini, and She-Sheng Xue. To be submitted to Phys. Rev. C.
- **On the outer crust of neutron stars**, R. Belvedere, Jorge A. Rueda, Remo Ruffini, and She-Sheng Xue. To be submitted to Phys. Rev. D.
- **A self-consistent general relativistic Thomas-Fermi treatment of neutron stars cores**, Jorge A. Rueda, D. Pugliese, Remo Ruffini, and She-Sheng Xue. To be submitted to Phys. Rev. D.
- **The effect of critical fields on the properties of electromagnetic black holes within the Euler-Heisenberg approach**, Jorge A. Rueda, Remo Ruffini, and She-Sheng Xue. To be submitted to Phys. Rev. D.

- **The general relativistic Thomas-Fermi model of white-dwarfs**, Jorge A. Rueda, Michael Rotondo, Remo Ruffini, and She-Sheng Xue. To be submitted to Phys. Rev. D.
- **A self-consistent general relativistic solution for a self-gravitating system of degenerate neutrons, protons and electrons in beta equilibrium**, Jorge A. Rueda, M. Rotondo, Remo Ruffini, and She-Sheng Xue. Submitted to Phys. Rev Lett.
- **On the self-consistent equilibrium equations of neutron stars**, Jorge A. Rueda, Remo Ruffini, and She-Sheng Xue. Submitted to Phys. Rev Lett.
- **On the relativistic Thomas-Fermi treatment of compressed atoms and compressed nuclear matter cores of stellar dimensions**, Michael Rotondo, Jorge A. Rueda, Remo Ruffini, and She-Sheng Xue. Submitted to Phys. Rev C.
- **A self-consistent approach to neutron stars**, Jorge A. Rueda, Michael Rotondo, Remo Ruffini, and She-Sheng Xue. J. Korean Phys. Soc. 57, 560 (2010).

Contributions to the Proceedings of Meetings and Workshops
- **A general relativistic Thomas-Fermi treatment of neutron stars cores I. The case of non-interacting particles**, Jorge A. Rueda, D. Pugliese, Michael Rotondo, Remo Ruffini, and She-Sheng Xue. To be published in Int. J. Mod. Phys. D as a contribution for the Proceedings of the 2nd Galileo-Xu Guantqi Meeting, Ventimiglia-Italy (2010).
- A general relativistic Thomas-Fermi treatment of neutron stars cores II. Generalized Fermi energies and beta equilibrium in the strongly interacting case, **Jorge A. Rueda, D. Pugliese, Michael Rotondo, Remo Ruffini, and She-Sheng Xue. To be published in Int. J. Mod. Phys. D as a contribution for the Proceedings of the 2nd Galileo-Xu Guantqi Meeting, Ventimiglia-Italy (2010).**
- On the electrostatic structure of neutron stars, **Jorge A. Rueda, Remo Ruffini, and She-Sheng Xue. AIP Conf. Proc. 1205, 143 (2010).**