Pugliese Daniela

Position: Ph.D. Student

Period covered: 2007-2010

I Scientific Work

My actual research activity is related to the study of the self-gravitating systems of elementary particles. In particular I considered static, spherically symmetric self-gravitating (cold) systems of scalars minimally coupled to a U(1) gauge field (charged boson stars). They are localized solutions of the coupled system of Einstein and general relativistic Klein-Gordon equations of a complex scalar field with a local U(1) symmetry. The study of boson stars were first introduced by Ruffini and Bonazzola in 1969. They used field quantization of a real scalar field and, considering the ground state of N particles, they found for spherical symmetric equilibrium, the solutions of the Einstein-Klein- Gordon equations. A method of self-constituent field was used to study the equilibrium configurations of a system of self-gravitating scalar bosons and fermions in their ground state without considering the traditional perfect fluid approximations or equations of state. The general relativistic treatment eliminates completely some difficulties present in the non relativistic Newtonian approximation, where it was noted that at an increase of number of particles correspond an increase of the total energy of the system until the energy reaches a maximum value and then decreases to negative values. Furthermore from this analysis it was also evident that one cannot treat such a system of many bosons (with a constant temperature) as perfect fluid since the pressure of the system is anisotropic. On the other hand this treatment introduced for the fist time the concept of a critical mass for these objects. In fact as for other compact objects as white dwarfs and neutron stars, there is a critical mass and a critical number of particle , below which this system is stable against complete gravitational collapse to a black hole. In my study particular attention is given to the analysis of the stability and equilibrium of this systems in particular for values boson charge near the critical values and for different values of the mass-charge ratio of these systems.

In general, attention is due to the problem of stability of matter, bosons or fermions, confined by its self-generated gravity. Gravitational attraction for spherically symmetric self gravitating systems of scalars(charged as neutral) counter{balances the repulsion due to kinetic energy. On the other hand, Heisenberg uncertainty principle prevent neutral boson stars from a complete gravitational collapse, meanwhile the radius R should satisfy the condition $R>3R_S$ where R_S is Schwarzschild radius, to avoid complete gravitational collapse. Stable charged boson stars can exist if the gravitational attraction is larger than the Coulomb repulsion: if the repulsive Coulomb force is bigger than the attractive gravitational one the system should be instable. Moreover as for other charged objects, if the radius of these systems is less than the electron Compton wavelength and if is super critically charged then pair production of electrons and positrons occurs.

A great interest is involved in this study of the phenomena related to the formations and stability of self-gravitating systems. Compact objects play an important role in the astrophysical researchand also they involve a great amount of physic of nuclei and of elementary particles. Moreover some authors conjectured that a boson stars could model a self-gravitating Bose-Einstein condensate on an astrophysical scale. These systems provide also an ideal model to investigate the behaviour of elementary particles in the context of general relativity, involving the study of field equations on a semi-riemannian manifold and in particular for the charged boson stars the Einstein-Maxwell equations. On the other hand if no fundamental elementary scalar particle has been detected so that the existence of the spin 0-particles is still an open issue, nevertheless in the theory of Glashow-Weinberg-Salam, a real scalar particle, the Higgs particle after symmetry breaking is introduced. Moreover the study of gravitational equilibrium solutions of scalar fields is motivated also by the idea that the collapse of charged compact objects of bosons in principle could to lead charged black holes. In this way these configurations may represent also an initial condition for the process of gravitational collapse and in many respects of the physic of black hole as for example in the explanation and modelling of gamma ray emission (GRBs)that postulates the existence of critical and overcritical (electrical) fields in black holes in order to extract their blackholic energy. After the numerical resolutions of the Einstein-Klein-Gordon-Maxwell equations for different values of the radial function at the origin and for different values of the charge, I focused attention on the stability of these configurations for boson charge near or greater the critical valued. In particular, from the numerical integrations it is evident that stable charged configurations of self{gravitating charged bosons are possible even with particle charge $q = q_{crit}$. It is also evident for different values of $q > q_{crit}$ stable solutions without nodes are possible only for little value of central density; meanwhile for value $q > q_{crit}$ and higher central densities the boundary conditions at the origin are not more satisfied, only stable configurations for solutions with one or more nodes are possible. The behaviour of the radius such as the total charge and mass of the system near the critical point is studied. In this line the future analysis is also devoted to the study of a generic quantized system of boson and anti-bosons such as charged self-gravitating fermions.

II Conferences and educational activities

December 2007-July 2008 :

- Fisica gravitazionale II *by Prof. R. Ruffini*

- Fisica teorica II: relatività generale, cosmologia, collasso gravitazionale *by Prof. R. Ruffini*

- Fisica teorica III: buchi neri, polarizzazione del vuoto, Big Bang e cosmologia *by Prof. R. Ruffini*

- Fisica teorica: meccanica analitica *by Prof G. Gallavotti*

– Cosmologia primordiale *by Dr G. Montani*

February 2008
- "Second Kolkata Conference on Observational Evidence for Black Holes in the Universe"
and
- "SNBNCBS-ICRANet workshop on Black Holes, Neuton Stars and Gamma Ray Bursts", February 10th-17th 2008, Kolkata.

July—August 2008

- "Third Stuckelberg Workshop", July 8-18 (2008) , Pescara, Italy.

- " XIII Brazilian school of cosmology and gravitation", 24 July- 02 August (2008) Mangaratiba Rio de Janeiro Brazil

September 2008
- "Probing stellar populations out to the distant Universe" 14-19 September, 2008 Cefalù Sicily

Given Talks and Seminars
July—August 2008
-***"Deformation of space—time metrics"***
Third Stuckelberg Workshop, July 8-18 (2008) , Pescara, Italy.