Dense Stellar Matter and Structure of Neutron Stars

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After giving an overview of the history and idea of neutron stars, I shall introduce, in part one of my lectures, a representative collection of models for the equation of state of super dense neutron star matter, which account for various physical possibilities concerning the unknown behavior of such matter. Part two of my lectures deal with the construction of models of static as well as rapidly rotating neutron stars, and an investigation of the cooling behavior of such objects. Both is performed in the framework of Einstein's theory of general relativity. For this purpose the broad collection of models for the equation of state, derived in part one, will be used as an input. Various computed neutron star properties (e.g., masses, radii, moments of inertia, red and blue shifts, limiting rotational periods, cooling behavior) will be compared with the body of observed pulsar data. Finally, part three deals with an investigation of the properties of stars made up of absolutely stable strange quark matter. Their properties are compared with those of their nonstrange counterparts, i.e., neutron stars.

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From Quark Matter to Strange Machos

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This paper gives an overview of the properties of all possible equilibrium sequences of compact strange-matter stars with nuclear crusts, which range from strange stars to strange dwarfs. In contrast to their non-strange counterparts, – neutron stars and white dwarfs –, their properties are determined by two (rather than one) parameters, the central star density and the density at the base of the nuclear crust. This leads to stellar strange-matter configurations whose properties are much more complex than those of the conventional sequence. As an example, two generically different categories of stable strange dwarfs are found, which could be the observed white dwarfs. Furthermore we find very-low-mass strange stellar objects, with masses as small as those of Jupiter or even lighter planets. Such objects, if abundant enough in our Galaxy, should be seen by the presently performed gravitational microlensing searches.

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Implications of Hyperon Pairing for Cooling of Neutron Stars

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The implications of hyperon pairing for the thermal evolution of neutron stars containing hyperons are investigated. The outcome of cooling simulations are compared for neutron star models composed only of nucleons and leptons, models including hyperons, and models including pairing of hyperons. We show that lambda and neutron pairing suppresses all possible fast neutrino emission processes in not too massive neutron star. The inclusion of lambda pairing yields better agreement with X-ray observations of pulsars. Particularly, the surface temperatures deduced from X-ray observations within the hydrogen atmosphere model are more consistent with the thermal history of neutron stars containing hyperons, if the critical temperature for the onset of lambda and nucleon pairing is not too small.

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