HAW05-2005-000594

Abstract for an Invited Paper
for the HAW05 Meeting of
the American Physical Society

Nuclear equation of state from neutron star structure and cooling

JAMES LATTIMER, Stony Brook University

Neutron stars represent the ultimate laboratory for the study of dense matter, especially neutron-rich dense matter. Such matter may exhibit phenomena and conditions not observed anywhere else in the universe, such as hyperon-dominated matter, deconfined strange quark matter, superfluidity and superconductivity, opaqueness to neutrinos, and extreme magnetic fields. To date, the two most important properties of neutron stars, their typical radii and their maximum mass, remain elusive. The determination of each would yield important information about two different aspects of dense matter, the radius being primarily a function of the isospin dependence of the nucleon-nucleon force near the nuclear saturation density, and the maximum mass depending upon the composition and stiffness of supranuclear matter. This talk will focus on how the structure of neutron stars (*i.e.*, the maximum mass, radii, moments of inertia, crustal thicknesses, and central densities) depends upon the equation of state and the composition of dense matter. In addition, it will summarize how recent observations are constraining these structural properties. These observations include radio and X-ray studies of binary pulsars, radio studies of pulsar glitches, X-ray and optical studies of the thermal emission from isolated neutron stars and pulsars, and observations of burst sources believed to be associated with the neutron star surface. Radio binary pulsars already yield several accurate mass measurements, and several more estimated masses, some of which challenge conventional wisdom concerning the maximum neutron star mass. In addition, the potential exists to measure the moment of inertia of at least one neutron star (PSR J0737-3039) in a radio binary which could provide a radius determination of unprecedented accuracy. Glitches from pulsars can help determine the thickness of neutron star crusts, which depends upon the stellar mass and radius, as well as the unknown pressure at the core-crust interface at approximately one half of the nuclear saturation density. Thermally emitting sources yield valuable data about the redshifted area, redshifted temperatures, and ages of the emitting sources, which in turn proffer information about the cooling histories of neutron stars. Neutron star cooling indirectly informs us about the internal composition and the superfluid properties of dense matter. Burst sources, including quasi-periodic oscillators, may convey surface redshift data, which together with radiation radius information, will yield neutron star masses and radii. Parallel constraints from laboratory data, such as nuclear binding energies, dipole resonance energies, and neutron skin thickness determinations are also discussed for comparison.