DNP06-2006-000034
Abstract for an Invited Paper
for the DNP06 Meeting of
the American Physical Society

Neutron Star Structure From Observations[1]

JAMES LATTIMER, Stony Brook University

Neutron stars are laboratories for dense matter physics. Observations of neutron stars, in the form of radio pulsars, X-ray binaries, X-ray bursters, and thermally-emitting isolated stars, are rapidly accumulating. Especially interesting are the radio pulsars PSR J0751+1807, Terzan 5 I and Terzan 5 J (with suprisingly large measured masses of $2.1 \pm 0.2, 1.69 \pm 0.1$ and 1.85 ± 0.05 solar masses, respectively), the pulsar PSR J1748-2446ad with the most rapid spin rate of 716 Hz, and the radio pulsar binary PSR J0737-3039 for which a moment of inertia of one of the neutron stars might be measured within a few years. Extremely massive neutron stars are important because they set limits to the maximum mass and upper limits to the maximum density found in cold, static, objects, and might limit the appearance of exotic matter such as hyperons, Bose condensates or deconfined quarks in a star's interior. The spin rate sets an upper limit to the radius of a star of a given mass, and the moment of inertia, being roughly proportional to MR^2, is a sensitive measure of neutron star radius. While the maximum mass speaks to the relative stiffness of the high-density equation of state at several times nuclear matter density, the radius is a measure of the relative stiffness of the low-density equation of state in the vicinity of the nuclear saturation density. For the nearly pure neutron matter found in neutron stars, it is a direct measure of the density dependence of the nuclear symmetry energy. Other promising observational constraints might be obtained from neutron star seismology (which limits the relative crustal thickness) and Eddington limited fluxes observed from bursting sources, and from thermal emissions from cooling neutron stars. The latter have the potential of constraining $R_\infty = R/\sqrt{1 - 2GM/Rc^2}$ if the source's distance can be accurately assessed. The distances of two nearby isolated sources, RX J1856-3754 and Geminga, have been determined by parallax. However, there are major difficulties in accounting for atmospheres of unknown composition and uncertain magnetic field strenghs for these stars. The distances to several distant X-ray emitting neutron stars have also been estimated with some precision because they are members of globular clusters, These sources have advantages because, having undergone recent accretion, they should have relatively weak surface magnetic fields and hydrogen-dominated atmospheres. Preliminary results from the interpretation of thermal emissions indicate consistency with a radius in the range of 10-15 km, but only a restricted subset of possible equations of state can account for the (M, R) constraints of all the sources.

[1]DOE grant DE-FG02-87ER-40317