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The future of neutron rich matter in heaven and earth

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Neutron stars and other compact astrophysical objects are made of neutron rich matter. We describe a variety of laboratory experiments that indirectly probe neutron rich matter using beams of electrons, heavy ions, and radioactive isotopes. The Parity Radius Experiment (PREX) aims to measure the neutron radius of ^{208}Pb using parity violating electron scattering. Precisely measuring the neutron rich skin of a heavy nucleus determines the density dependence of the symmetry energy, or how the energy rises for systems with excess neutrons. This has many implications for the crust, composition, radius, and cooling rate of neutron stars. PREX is a precision experiment on a stable nucleus and yields complimentary information to experiments with neutron rich radioactive beams. Next, we present semiclassical molecular dynamics simulations of the nonuniform neutron rich matter in the inner crust of a neutron star. This complex matter is called nuclear pasta and results from competition between nuclear attraction and coulomb repulsion. Pasta phases are closely related to the multiple large fragments formed in some heavy ion collisions. The properties of pasta may be important for the electromagnetic, neutrino, and gravitational radiations of neutron stars. Finally, we present the model independent equation of state of low density nuclear matter based on the virial expansion using nn, n-alpha, and alpha-alpha elastic scattering phase shifts.