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Probing neutron rich matter with parity violation[1]

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Many compact and energetic astrophysical systems are made of neutron rich matter. In contrast, most terrestrial nuclei involve approximately symmetric nuclear matter with more equal numbers of neutrons and protons. However, heavy nuclei have a surface region that contains many extra neutrons. Precision measurements of this neutron rich skin can determine properties of neutron rich matter. Parity violating electron scattering provides a uniquely clean probe of neutrons, because the weak charge of a neutron is much larger than that of a proton. We describe first results and future plans for the Jefferson Laboratory experiment PREX that measures the thickness of the neutron skin in 208Pb. Another JLAB experiment CREX will measure the neutron radius of 48Ca and test recent microscopic calculations of this neutron rich 48 nucleon system. Finally, we show how measuring parity violation at multiple momentum transfers can determine not just the neutron radius but the full radial structure of the neutron density in 48Ca. A neutron star is eighteen orders of magnitude larger than a nucleus (km vs fm) but both the star and the neutron rich nuclear skin are made of the same neutrons, with the same strong interactions, and the same equation of state. A large pressure pushes neutrons out against surface tension and gives a thick neutron skin. Therefore, PREX will constrain the equation of state of neutron rich matter and improve predictions for the structure of neutron stars.

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