THE LEAD RADIUS EXPERIMENT AND NEUTRON RICH MATTER IN ASTROPHYSICS AND IN THE LABORATORY

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ORGANISERS:
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NUMBER OF PARTICIPANTS: 38

MAIN TOPICS:

- The PREX Parity Violating Experiment
- Neutron densities and Nuclear Structure
- Atomic Parity Violation and Neutron Densities
- Neutron rich matter in Astrophysics

SPEAKERS:

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J. Lattimer (*Stony Brook*),
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W. Lynch (*East Lansing*),
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SCIENTIFIC REPORT:

Aim and Purpose: The Lead Radius Experiment (PREX) uses parity violation to accurately determine the radius of the neutron distribution in ^{208}Pb. This measurement has remarkably broad implications for nuclear structure, astrophysics, atomic parity violation, and low energy tests of the Standard Model. The purpose of this workshop was to review final plans for PREX and to discuss the experiment's many implications. In addition, we aimed to improve communication between electron scattering, nuclear structure, astrophysics, and atomic parity communities and between North American and European researchers. The program involved many experimentalists, in addition to theorists, and emphasized the close interplay between theory and experiment. We thank the participants for their excellent talks and for the intensive discussions.

Results and Highlights: Many predictions were made for the neutron skin thickness (difference between neutron and proton radii) of ^{208}Pb including those based on antiproton-nucleus scattering, semi-empirical mass formula fits, the strength of the Pygmy resonance, and a review of proton-nucleus scattering. In addition, extracting matter radii from electro-pion production was discussed. The skin thickness in ^{208}Pb was shown to be strongly correlated with skin thicknesses in nuclei of interest for atomic parity experiments. In addition, it was shown that while deformation can increase both neutron and proton radii, it has very little effect on the skin thickness. Advances in nuclear structure were presented including more accurate microscopic mass formulas and a more systematic construction of a universal energy density functional. In a previous workshop at Jefferson Laboratory in 2008 (see http://conferences.jlab.org/PREX) the neutron radius of ^{208}Pb was shown to have implications for many neutron star properties such as the transition density between solid crust and liquid interior, and the possibility of rapid neutrino cooling via the direct URCA process. In the present workshop, updates were presented on measuring neutron star radii, which may require more sensitive X-ray telescopes, and on possibilities to extract properties of neutron rich matter from neutron star shear oscillations, crust cooling, and gravitational wave observations.

Possibilities for a follow on measurement to the planned ^{208}Pb experiment were discussed, including other nuclei, a higher momentum transfer, or measuring with improved precision. Measurements for both ^{48}Ca and ^{120}Sn appear feasible. Measurement of the neutron radius in ^{208}Pb with an im-

proved accuracy of $\pm$ 0.03 fm, compared to the planned $\pm$ 0.05 fm, may be possible with a large experimental effort.

Conclusions: The Lead Radius Experiment (PREX) impacts an extraordinary variety of research areas in nuclear physics, atomic physics, and astrophysics, and its results could have significant impact. A follow on measurement that increases the accuracy of the original experiment beyond the planned 0.05 fm, could increase the physics payoff even further, and should be considered. Nuclear physicists and astrophysicists have important common interests in the study of neutron rich matter and measurements in both areas of research will help to constrain theoretical predictions in either regime. This requires close contact between the two groups. Thus some kind of electronic community should be established to improve communication and foster collaborations. New astrophysical facilities, such as the International X-ray Observatory (IXO) or the Advanced Laser Interferometer Gravitational Wave Observatory (LIGO), promise unique and exciting information on neutron rich matter, while advances in nuclear structure promise improved descriptions of neutron stars and their crusts.

The workshop talks can be browsed from the website: http://www.ect.it or at http://cecelia.physics.indiana.edu/ECT-PREX/Talks