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Illuminating nuclei for neutron stars[1]

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The coming decades are set to provide a much deeper understanding of nuclei and neutron stars. The recent observation of neutron star mergers with gravitational and electromagnetic messengers opens a new window to investigate hadronic matter at high densities. The atomic nucleus provides a mini laboratory to extract physical quantities relevant to our understanding of neutron star physics, such as the equation of state for neutron rich matter and also the role of hadronic degrees of freedom beyond the nucleon. Experiments on atomic nuclei at the latest generation of electromagnetic beam facilities, such as the Jefferson Laboratory (USA) and MAMI (Germany), can address long standing issues in the field. The spatial distribution of neutrons in nuclei is known to a much poorer accuracy than the corresponding proton distribution. However, the difference in these distributions (the neutron skin when expressed as a difference in rms radii) constrains the density dependence of the symmetry energy, a parameter which also has a significant role in constraining neutron star structure, cooling and merger physics. In the talk I will outline the current status and future plans in our programme of neutron skin measurements with the Crystal Ball at MAMI. The intense polarized electromagnetic beams, large acceptance detector systems and nucleon spin polarimeters available at modern facilities also offer the opportunity to investigate the role of non-nucleonic degrees of freedom. These may emerge at the higher densities involved in the cores of heavy neutron stars and the high matter densities experienced in mergers. Our recent results obtained at MAMI and Jefferson Lab will be presented along with plans for the future.

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