Rare isotopes unveil a new era in nuclear science

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Our Universe has a variety of visible matter made up with various types of nuclei that embodies nature's beauty of assembling the building blocks, protons and neutrons into various complex many-body objects. While much has been understood about the long-lived or stable nuclei, the neutron-proton asymmetric, short-lived nuclei, i.e. the rare isotopes, bring a wealth of new information. The reactions and decays of these isotopes drive the creation of majority of the heavy elements in our Universe and are the powerhouse of exotic cosmic phenomena.

The presentation will outline how radioactive ion (RI) beams are allowing us to uncover the mysteries embedded in these rare isotopes. This is leading to revelation of unconventional forms of nuclei such as, nuclear halo and skin and fundamental changes of nuclear shells that break the bounds of our traditional knowledge.

The discussion will show examples of how both low-energy RI beams from Isotope Separator Online (ISOL) facilities and relativistic energy in-flight RI beams offer complementary avenues to discover new features in these exotic nuclei.

These unexpected features observed in the rare isotopes challenge our understanding of the residual strong force of nature binding the building blocks into the variety of nuclei. Addressing this fundamental question has been a century long challenge in which rare isotopes bring in a new dimension amplifying the neutron-proton asymmetric features of the force. The presentation will show how experimental studies of static and dynamic observables of rare isotopes can illuminate on variations from different prescriptions attempting to describe the nuclear force. The discovery of unconventional features of the rare isotopes forms the only guidance to build the true global model of nuclei that can be used to eventually understand the role of nuclear science at the extreme conditions in our Universe.

An outlook will be presented on some future prospects at new generation radioactive ion beam facilities that will extend our reach further for accessing rare isotopes in colliding and exploding stars.