Open refereed paper reveals how to study unstable radioactive nuclei's dual traits

November 16 2016

Radioactive nuclides, found within an atom's core, all share a common feature: they have too many or too few neutrons to be stable. In a new review published in *EPJ A*, Maria Jose Borges and Karsten Riisager explain how overcoming technical difficulties in accelerating such radioactive nuclei beams can help push back the boundaries of nuclear physics research. This fascinating topic is the first *EPJ A* paper to be subjected to an open referee process, whereby the referee's comments are included.

The authors outline how the new CERN project HIE-ISOLDE will reach the energy levels needed to make two nuclei overcome the electric repulsion between them - referred to as the Coulomb barrier. This means that it will be possible to design experimental tools to explore both single-particle and collective degrees of radioactive nuclei freedom. This will improve our understanding of the unique duality in the degrees of freedom, which no other state of matter exhibits.

The radioactive nuclei are generated at CERN, near the Franco-Swiss border, via the Isotope mass Separator On-Line facility (ISOLDE), which is a unique source of low-energy beams. Specifically, the HIE-ISOLDE project aims to raise the maximum energy of accelerated particles beyond the Coulomb barrier, to more than 10 megaelectron volts / atomic mass units (MeV/u).

In this review, the authors outline of the history of the project and then explain the nature of the superconducting linear accelerator used in HIE-

ISOLDE, giving further details on how physicists plan to improve the beam quality and intensity. Subsequently, the team is also planning to add superconducting cavities allowing for a deceleration of the beams to better control optimum energy for each reaction and tailor them, for example, to conditions found in the stars for astrophysics studies. Many other applications are pending and the review offers a sample of planned studies.

Ultimately, physicists aim to have a "dial-a-radioactive-nuclei beam" of the same quality as stable nuclei beams.

More information: M.J.G. Borge and K. Riisager (2016), HIE-ISOLDE, the project and the physics opportunities, *European Physical Journal A* 52: 334, DOI: 10.1140/epja/i2016-16334-4

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