Nuclei at Extreme Deformations and Configurations: Touching Horizons with On-Line Laser Spectroscopy

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Ion trapping has opened a plethora of research directions [1-3], and online laser spectroscopy experiments on short-lived isotopes have provided a wealth of information on changes in the nuclear radii and nuclear moments [4]. Here is a brief review of extreme nuclear configurations such as halo nuclei and extreme deformations, namely tri-axial nuclei. Examples include experiments on laser-cooled stored Be+ ions and collinear fast-beam laser spectroscopy on La^+ ions. Both measurements allow high precision by practically eliminating the Doppler effect.

At the moment, 11Be is the only one-neutron halo nucleus that can be approached by all the following three experimental methods: The interaction cross-section measurement, the isotope shift measurement of an optical transition, and the hyperfine anomaly measurement, which provide its matter radius, charge radius, and magnetization radius, respectively. High-energy radioactive beryllium isotope ion beams at 1 GeV were provided by the RIKEN projectile fragment separator RIPS [5]. Subsequently, Be+ ions were slowed and trapped, then cooled to micro eV and observed during their few second lifetimes [6]. The neutron deficient La isotopes are in the mass region where an axially asymmetric shape of nuclei is predicted theoretically. The axially asymmetric gamma parameters were calculated from Total Routhian Surfaces (TRS). To confirm the calculations, we have measured the hyperfine structure (HFS) and the isotope shifts of the neutron deficient La isotopes (Z=57) with collinear fast-beam laser spectroscopy. The electric quadrupole moment is particularly sensitive to the gamma degree of freedom. The experiments were started at JAEA for ^{137}La, ^{135}La and ^{133}La [7] and are continuing at the ISAC facility at TRIUMF for 131La, where we have measured the HFS of ^{131}La [8] and observed for the first time triaxiality in a nuclear ground state.

Möller and co-workers have performed finite-range liquid-drop model (FRLDM) calculations of axial asymmetry [9], finding new deformation parameters. There are some differences between the gamma parameters from the FRLDM and TRS calculations. For example, large triaxiality is predicted for ^{129}La from TRS, while axial symmetry from FRLDM. In order to clarify the deformation of ^{129}La and even more neutron-deficient La isotopes, we are now planning to extend the laser spectroscopy to these nuclides.

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