Contribution ID: **156** Type: **Invited Presentation**

Precision Mass Measurements of Nutron-rich Chromium Isotopes into the <i>N</i>=40 ”Island of Inversion”: From a New ”ISOL” Beam to ab-initio Shell Model Calculations.

Thursday, 1 June 2017 14:00 (15 minutes)

As first hinted at in the mid-seventies by pioneering on-line mass measurements of neutron-rich Na isotopes, the spherical shell, or sub-shell, gaps described within the shell model of the atomic nucleus are prone to rapid evolution with proton and neutron number. Far from being isolated, the region of shell erosion around <i>N</i>=20 is actually part of a larger “archipelago of islands of inversion”. One such island, around <i>N</i>=40, is thought to exhibit maximum quadrupole deformation for ⁶⁴Cr. However, the mass surface in the chromium chain, approaching <i>N</i>=40, remains too imprecisely known. Over the last thirty-years, on-line Penning-trap mass spectrometry associated with the “ISOL” production technique has proven to be a particularly successful tandem for the precise determination of the mass of exotic species. Although chromium was not considered to be a traditional thick-target “ISOL” element, successful laser-ionization developments^[1] combined with highly sensitive mass spectrometry techniques enabled the mass measurements of ⁵²⁻⁶³Cr, during two recent experimental campaigns at the ISOLDE facility, using the Penning-trap mass spectrometer ISOLTRAP^[2]. The mass values obtained are of greatly refined precision thus shining new light on the development of ground-state collectivity towards <i>N</i>=40 in the chromium chain. Very recently, an ab-initio method, rooted in the IM-SRG framework, has been developed enabling the derivation of shell-model Hamiltonians from first principles thus extending the reach of ab-initio calculations to mid-shell nuclei^[3]. A comparison of these state-of-the-art shell model calculations with our results will be presented.

References:

[1] Goodacre et al., Spect. Chimica Acta B, In Press (2017).
[2] Mukherjee et al., Eur. Phys. J. A 35, 1-29 (2008).
[3] Stroberg et al., Phys. Rev. Lett. 118, 032502 (2017).

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Session Classification: Breakout 2