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Trap-assisted laser spectroscopy and mass spectrometry of neutron-deficient platinum and iridium isotopes

In the last two decades, there have been significant advances in the laser spectroscopy of neutron-deficient nuclides around the lead isotopic chain (a recent view of the extent of the gathered data can be found in [1]). These measurements have revealed a rich and quickly shifting landscape, with the charge radii exhibiting sudden jumps and oscillations with the variation of neutron number as in the gold (Z = 79) and mercury (Z = 80) isotopic chains, signaling a competition between markedly different nuclear structures which are quasi-degenerate in energy. The first extension of the data below the neutron midshell in the two chains suggests a lifting of this quasi-degeneracy and a return to a droplet-type trend of charge radii ([1], [2]). The refractory character of elements with lower proton number (Z < 79) has however prevented an expansion of the studies towards the proton midshell, with the only successful measurements following a collection-decay-desorption method from a mercury primary beam (the COMPLIS experiment [3]). It remains unclear how this picture evolves toward the proton dripline, where the droplet-like trends still need confirmation. It is also unclear what happens closer to the proton midshell, where full nuclear collectivity is expected to emerge.

With its intense primary beams and gas-cell method, the S3 spectrometer offers a promising alternative for the study of refractory elements, using fusion-evaporation reactions that favor the production of very neutron-deficient isotopes and gas-flow-based extraction which is not affected by the elements'refractory character. The very good spectral resolution of the gas-jet laser ionization and spectroscopy technique [4] offers an additional strength to study odd isotopes with complicated hyperfine structures, without sacrificing the simplicity of the in-source laser-spectroscopy technique.

In this Letter of Intent, we propose a program to study the refractory elements platinum and iridium combining the strengths of the S3-LEB and DESIR facilities. The isotopes of interest can be produced by a range of reactions, including 58,60Ni on an enriched or natural Sn target, both components of which will be available in the first years of the S3 operation. Isotopes having no long-lived isomeric states can be studied directly with S3-LEB and the PILGRIM mass spectrometer or the SEASON decay station. Isotopes with very low-lying isomers, such as 168-176Ir would be detected using the PI-ICR technique at the DESIR Penning-trap installations, which would allow both an individual determination of their hyperfine structure and first-time mass measurements. In addition, high-resolution alpha spectroscopy can be performed on the isotopes of Ir using the in-trap development of a DESIR Penning-trap mass spectrometer. As shown in [5], the combination of high-resolution mass spectrometry and laser spectroscopy can be crucial for the correct assignment of the ground-state charge radius. The sensitivity of the PI-ICR technique would be key if the high-spin and low-spin states of the Ir isotopes are populated very asymmetrically in the reaction. DESIR could also benefit the program by opting for a broadband production method (with a natural Sn target) and exploiting the powerful separation capability of the HRS. Although clearly stepwise and long-term, this program can help develop through the beams of refractory elements a unique niche of production and research for the broader S3-LEB/DESIR programs.

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