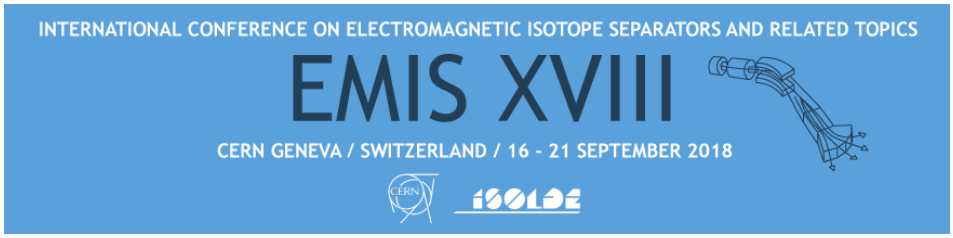

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First demonstration of Doppler-free two-photon in-source laser spectroscopy at the ISOLDE-RILIS

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The ISOLDE on-line mass separator facility at CERN has offered radiogenic beams of a multitude of elements for over 50 years [1]. Fundamental research on nuclear structure, masses and decay modes are carried out by the various experimental installations inside the hall. To complement these, several measurement campaigns throughout the past years have been conducted by the in-source laser ionization spectroscopy collaboration between teams of the Resonance Ionization Laser Ion Source (RILIS), the Windmill alpha-detector setup, ISOLTRAP and, more recently, the Isolde Decay Station (IDS). Studies performed by this collaboration have made a great impact on our knowledge of nuclear shape evolution along isotopic chains in the gold-astatine region [2]. The high sensitivity of the in-source resonance laser ionization method has enabled us to extend our reach towards the most exotic isotopes ever studied at ISOLDE, close to the proton drip line.
Doppler-broadening inside the hot cavity ion source environment remains the biggest drawback of this method, limiting the achievable resolution and thereby restricting its use to the study of the heavier isotopes, or to specific cases where the isotope shift or hyperfine structures are sufficiently large. A Doppler-free approach has been tested for the first time at ISOLDE, making use of two counter propagating laser beams, which are both required to excite a two-photon transition. The resolution is then limited by the laser linewidth because the Doppler-shifts seen by two photons are of equal magnitude and opposite direction, thereby summing to zero. This approach will open the door to high-resolution and high sensitivity in-source laser spectroscopy studies across the nuclear chart. Since we are restricted to ionization pathways involving two-photon transitions, this technique is complementary to the other laser spectroscopy experiments at ISOLDE.
Here we report on the first demonstration of this method inside the ISOLDE target-ion-source assembly using a newly developed injection seeded ring Ti:Sa laser cavity for reduced laser linewidth. The Doppler-free spectra of silicon stable isotopes have been obtained, repeating a historical study that was carried out inside an independent atomic beam apparatus [3]. By making use of the same ionization scheme, we were able to provide a benchmark for comparison of the resolution and extracted nuclear data. Based on this initial feasibility study the scope of applicability of the Doppler-free two-photon spectroscopy technique at the ISOL facilities will be discussed and presented.
[1] *M. J. G. Borge and K. Blaum*, https://doi.org/10.1103/PhysRevA.88.052510
[2] See references in: *V. Fedosseev et al.*, https://doi.org/10.1088/1361-6471/aa78e0
[3] *K. Wendt et al.*, https://doi.org/10.1103/PhysRevA.88.052510

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