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The PI-LIST: High-Resolution Crossed-Beams Laser Spectroscopy inside the ISOLDE Laser Ion Source

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Laser resonance ionization spectroscopy is a sensitive tool for investigating nuclear structures [1], but its spectral resolution is limited by Doppler broadening, which becomes significant at ion source temperatures of approximately 2000℃. This can limit resolution to 1-10 GHz, making it difficult to measure nuclear magnetic and quadrupole moments.
A new laser ion source design has been implemented at ISOLDE to provide in-source spectroscopy capabilities with higher resolution than previously achievable. It is based on the high beam purity Laser Ion Source and Trap (LIST) [2, 3], featuring spatial separation of the hot cavity where potential ion beam contamination can arise from non-laser related ionization mechanisms such as surface ionization. This design features the Perpendicularly Illuminated LIST (PI-LIST) [4], which uses a crossed laser/atom beam geometry for spectroscopy, resulting in only the transverse velocity spread of the atom ensemble contributing to the experimentally observed Doppler broadening. This allows for spectral resolutions down to 100-200 MHz, an order of magnitude below usual limitations. This technique was used to study neutron-rich actinium isotopes with the highest spectral resolution ever achieved for in-source resonance ionization spectroscopy at ISOLDE, CERN.[5] Technical implementation challenges and limits, such as efficiency loss, will also be discussed.
[1] V. Fedosseev et al., J. Phys. G: Nucl. Part. Phys. 44 084006 (2017)
[2] D. Fink et al., Nucl. Instr. Meth. B, 317 B, 417-421 (2013)
[3] D. Fink et al., Phys. Rev. X 5, 011018 (2015)
[4] R. Heinke et al., Hyperfine Interact 238, 6 (2017)
[5] E. Verstraelen et al., Phys. Rev. C 100, 044321 (2019)

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I have read the Code of Conduct to attend ICIS2023.

Yes

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