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Laser spectroscopy of recirculating beams at the TSR

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Laser spectroscopy is an atomic technique, which gives access to nuclear observables independently of nuclear models. The hyperfine structure reveals the nuclear spin and nuclear electromagnetic moments, while the isotope shift between any two isotopes is related to the change in the nuclear mean square charge radius.

There are limitations to laser spectroscopy related to the atomic system probed. First, the isotope of interest has to be delivered as a single atom (or ion), while some elements at ISOLDE are rather extracted and ionised as molecules. Second, the studied atomic transition has to be accessible with existing laser technologies, with a wavelength close to the visible range, as well as involving an electron orbital, which overlap with the nucleus provides the sensitivity required for the measurement. Finally, the extraction of the nuclear observables is often limited by the knowledge of the atomic parameters, which cannot be exactly calculated beyond a 3-electron system.

The TSR at ISOLDE offers the solution to these limitations in a number of cases. Molecules can be broken down in the EBIS, so that single-isotope ions are delivered to the TSR. The EBIS can also produce high charge states that provide simplified electronic systems, for which the atomic parameters can be calculated. Finally, the high and adjustable velocity of the ion beam allows to tune the Doppler shift by which visible light can be used in the laboratory to probe deep ultra-violet transitions of interest in these ions. A science programme is currently being developed, focused on halo-like structures in boron, carbon, and oxygen.

Additionally, it may be envisioned to use the laser spectroscopy technique at the TSR to polarise the stored ion beam in order to support the transfer reaction programme.

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