LASER IONISATION IN THE MARA-LEB GAS CELL

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Motivation

MARA-LEB (Mass Analysing Recoil Apparatus - Low Energy Branch) [1] is a facility that will be an extension for the MARA separator [2] at JYFL. MARA is a vacuum-mode electromagnetic separator with a high mass-resolving power, ideal to study medium-heavy nuclei.

MARA-LEB will be used to study proton-rich nuclei close to the drip-line. This area is of interest as a fertile ground to test the predictions of the shell model, proton-neutron interaction and shape-coexistence. Knowledge on these nuclei is of paramount importance to increase the understanding of the astrophysical rapid proton capture process [3].

MARA-LEB will provide the efficiency and selectivity required to study such exotic nuclei.

[1] P. Papadakis *et al.*, AIP Conf Proc **2011**, 070013 (2018)

[2] J. Sarén *et al.*, Nucl Instrum Meth B **266**, 4196 (2008)

[3] H. Schatz and W.-J. Ong, Astrophys J **844**, 139 (2017)

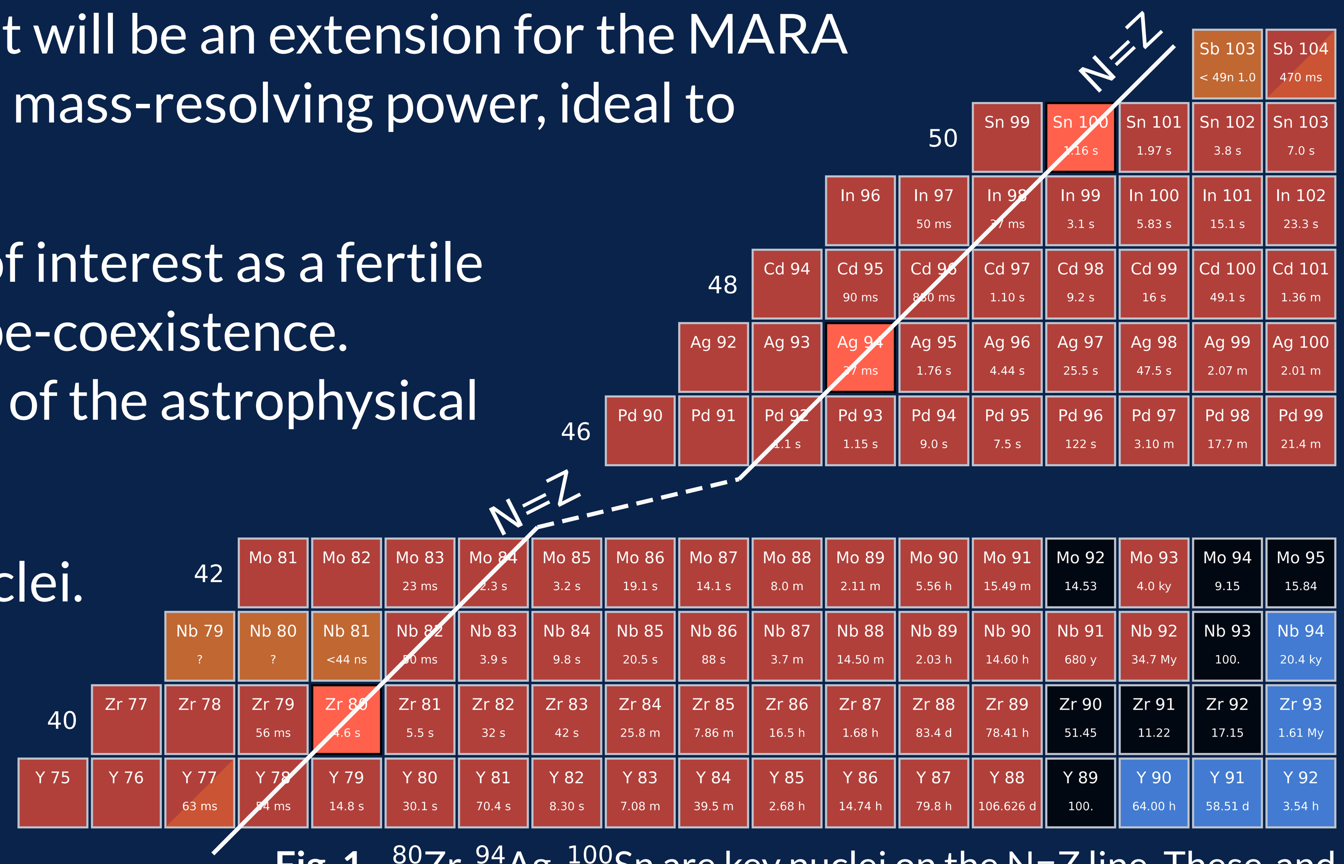

Fig. 1 - ^{80}Zr, ^{94}Ag, ^{100}Sn are key nuclei on the N=Z line. These and surrounding nuclei are of particular interest to MARA-LEB.

Setup

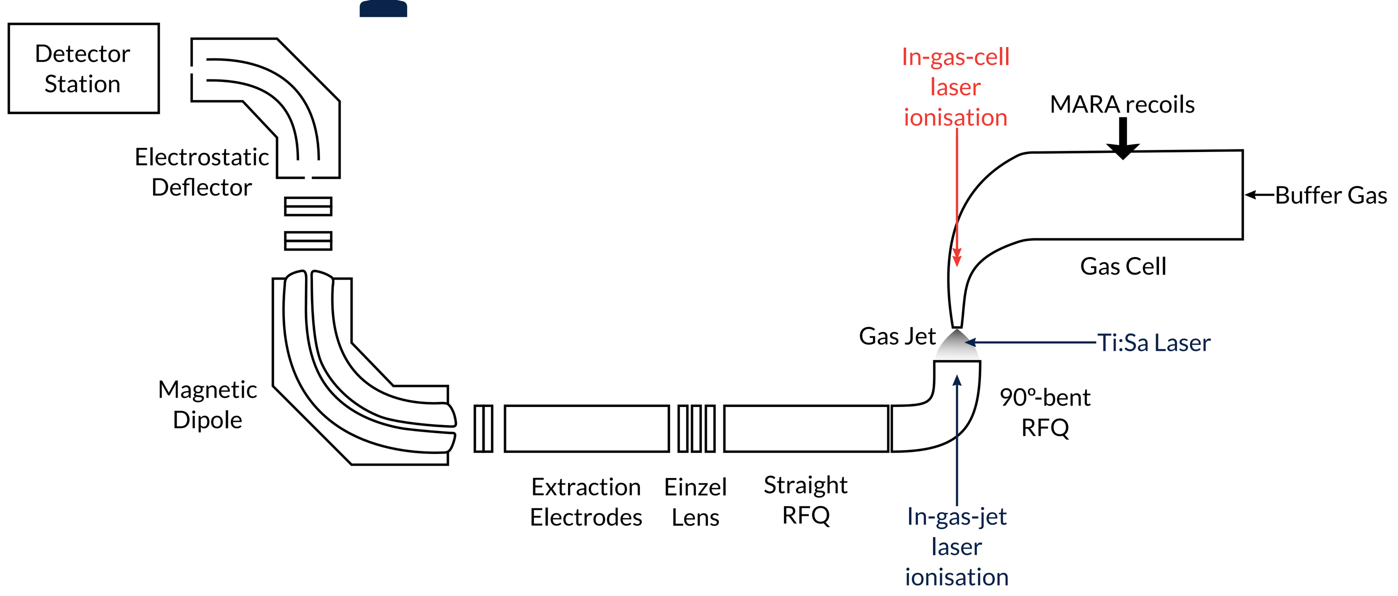

Fig. 2 - Schematic representation of the MARA-LEB beamline. Lasers for in-gas-cell ionisation (orange) and for in-gas-jet ionisation (blue) are highlighted. Not to scale.

The Low-Energy Branch will complement the selectivity of the MARA separator with contaminant suppression by using a buffer gas cell in combination with in-gas-jet or in-gas-cell laser ionisation. A radio-frequency quadrupole (RFQ) ion guide system then extracts and transports the ions to further acceleration and mass selection before guiding them towards detector stations.

Incoming recoils from MARA are thermalised and neutralised in the gas cell by a buffer gas, typically helium or argon. The neutralised ions can be subsequently laser ionised inside the cell or in the supersonic gas jet at the output of the cell.

Laser ionisation tests

A bronze filament (89% copper, 11% tin) was installed inside the gas cell and resistively heated to thermoionise and desorb tin atoms. The gas cell was installed in the IGISOL target chamber at the Accelerator Laboratory in the University of Jyväskylä. This setup allows to test the different laser ionisation methods on tin, an element of interest for future MARA-LEB studies. Argon was used as a buffer gas, and in-gas-cell laser scans of both steps of the two-step laser ionisation scheme shown on Fig. 3 were taken at different gas pressures.

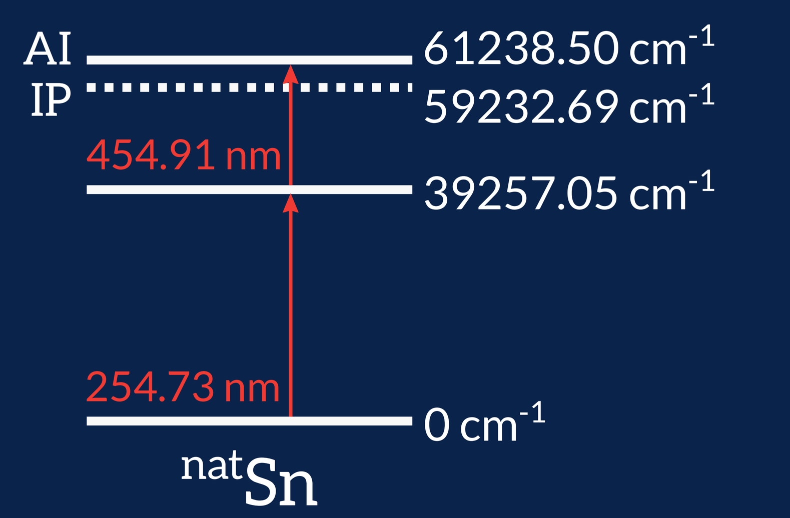

Fig. 3 - Resonance ionisation scheme for natural tin in terms of laser wavenumbers [4]. The wavelengths of the lasers used is shown overlaid in orange.

Pressure shift and broadening are observed on both steps (see Table 1). This demonstrates the need for in-gas-jet ionisation, in which these effects are less pronounced, to resolve the hyperfine structure of the ions while at the operating pressures of the gas cell, which are of the order of hundreds of mbar.

Table 1- Observed pressure shift and broadening of the lasers, extracted from laser scans fitted with a Voigt profile, shown in Fig. 4.

	Step 1	Step 2
Shift (MHz/mbar)	21(3)	51(3)
Broadening (MHz/mbar)	147(20)	122(29)

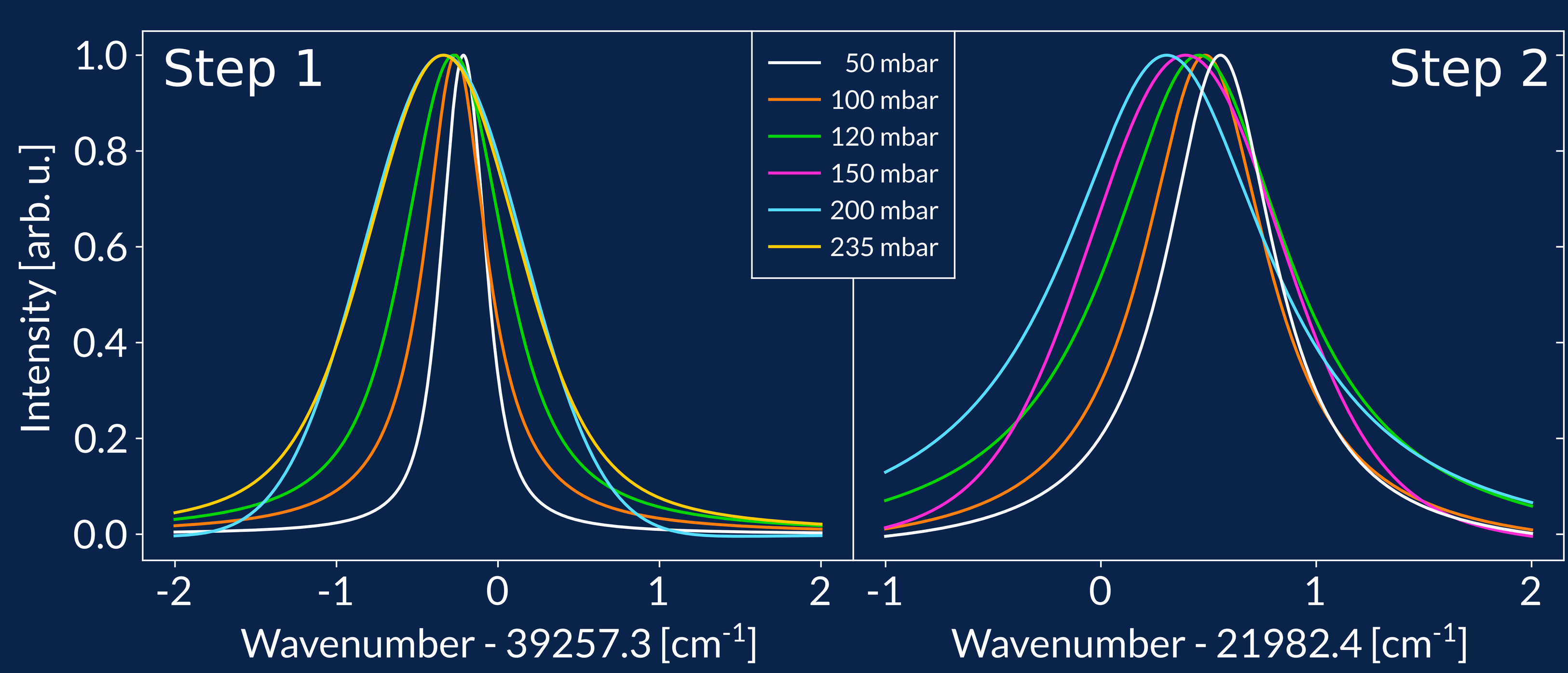

Fig. 4 - Laser scan Voigt fits at different buffer gas pressures for both the first (left) and second (right) steps of the resonant ionisation scheme. Wavenumber of the laser is given as the difference to the respective laser step wavenumber.

[4] A. Nadeem *et al.*, J Phys B **33**, 3729 (2000)

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