Developments towards high resolution spectroscopy of ^{235m}U

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MOTIVATION

The measurement of hyperfine structures and isotope shifts with high-resolution laser spectroscopy offers access to the extraction of fundamental nuclear structure properties including spins, mean-square charge radii and electromagnetic moments. Within the LISA framework, a new measurement campaign has been started on Uranium by means of collinear laser spectroscopy at IGISOL facility. The final aim is the study of the second lowest lying isomeric state in the nuclear landscape, that of the 76-eV isomer in ^{235}U

ALPHA RECOIL SOURCE DEVELOPMENT

To generate an isomeric beam a set of 27 molecular plated[1] ^{239}Pu alpha recoil sources have been produced at JGU and are currently under characterization to select the optimal one in terms of recoil effciency.

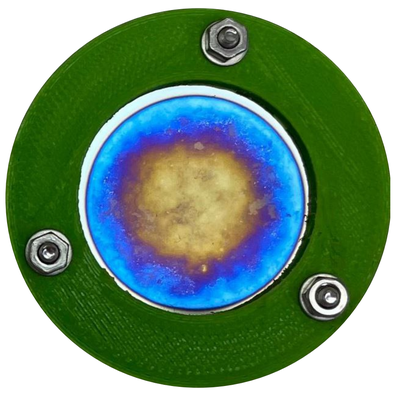

Fig. 1: Picture of a ^{239}Pu source on a 3D printed support

Sources characterization :

- Alpha spectrometry
- Gamma spectrometry
- RBS analysis
- TOF-ERDA

ACTINIDE GAS CELL

The sources will be used in the actinide Gas Cell[2] where the recoils are stopped in a buffer gas (He) and are extracted and guided to the IGISOL beamline for laser studies.

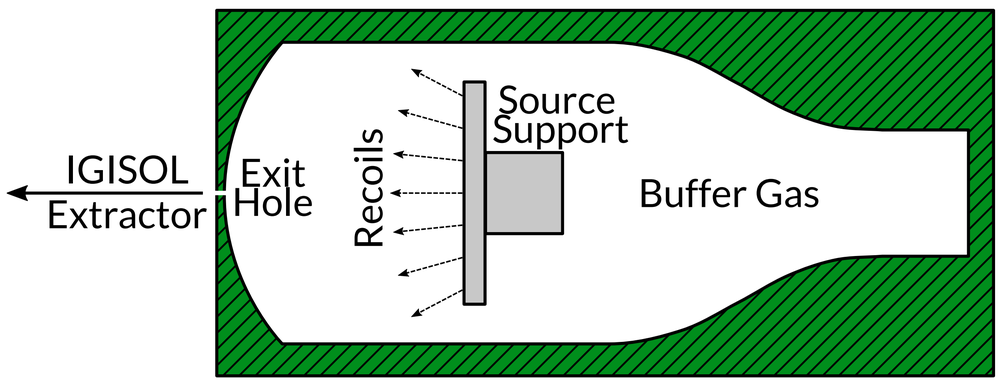

Fig. 2: Schematic representation of the Actinide gas cell with an alpha recoil source installed

COLLINEAR LASER SPECTROSCOPY

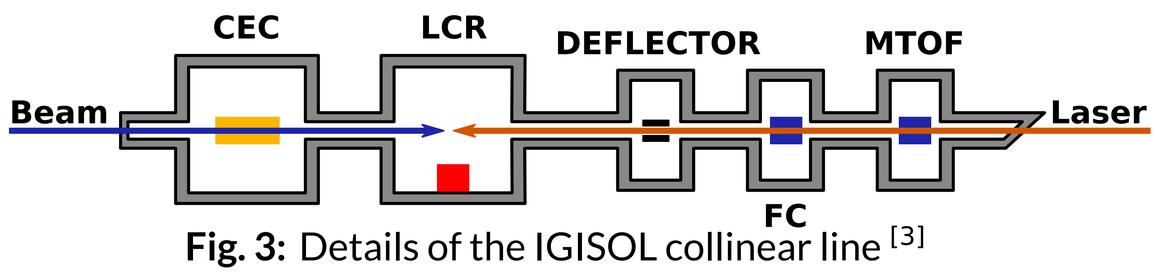

Fig. 3: Details of the IGISOL collinear line [3]

Detection of laser induced fluorescence allows the measurement of isotope shift and hyperfine structures.

GROUND STATE TEMPLATE

Using an electric discharge source placed in the IGISOL target chamber more than 10 atomic transition have been studied in the three natural Uranium isotopes : 234 (0.0054%), 235 (0.72%) and 238 (99.27%)

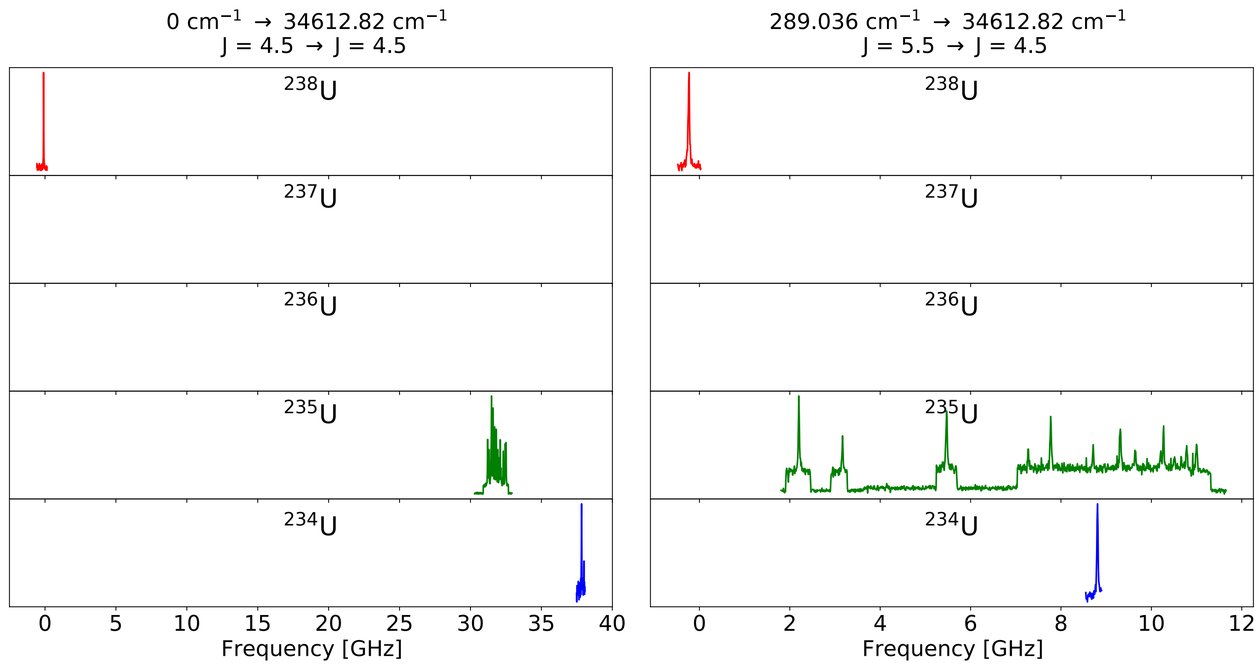

Fig. 4: Isotope shift representation for the three natural U isotopes in the 288.91 nm adn 291.34 nm transitions

ISOTOPE SHIFT $\delta\nu_i^{A,A'} = M_i \frac{A'-A}{A'A} + F_i \delta\langle r^2\rangle^{A,A'}$

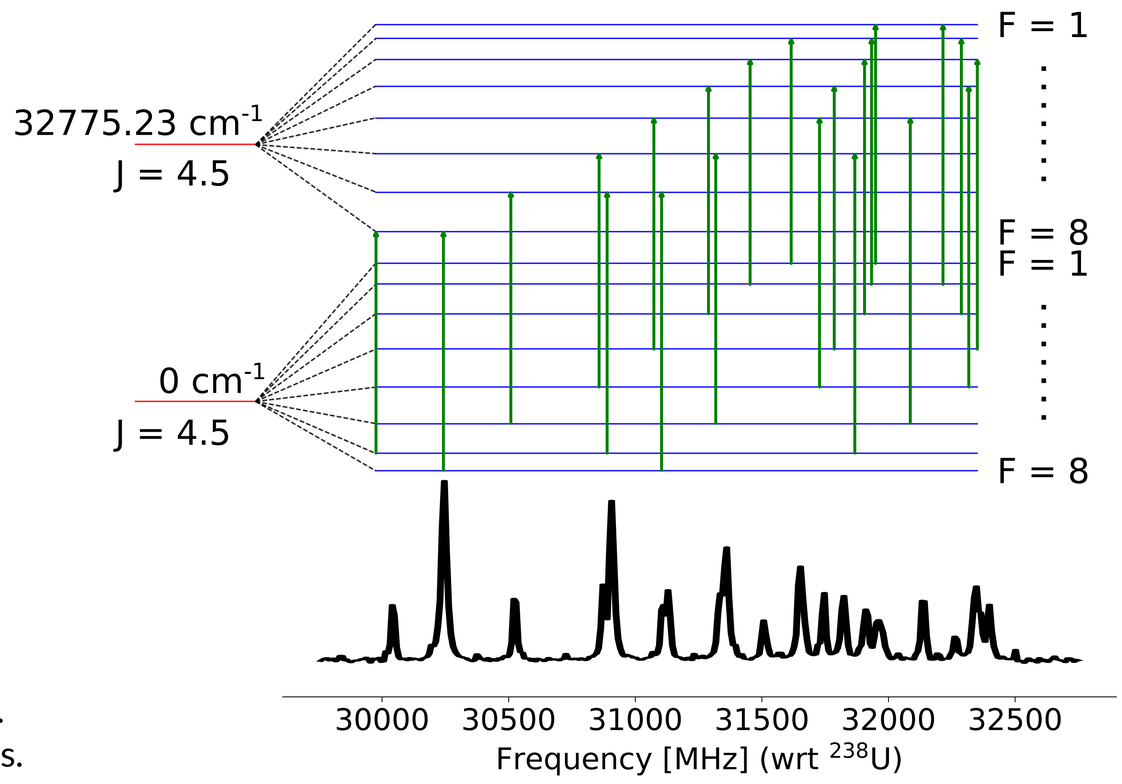

Fig. 5: ^{235}U hyperfine structure of the 305.02 nm transition

HYPERFINE SPLITTING $\Delta E_{\text{hfs}} = \frac{1}{2} A_{\text{hfs}} C + B_{\text{hfs}} \frac{\frac{3}{2}C(C+1) - 2I(I+1)J(J+1)}{2I(2I-1)2J(2J-1)}$

$C = F(F+1) - I(I+1) - J(J+1)$

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[3] De Groote, R. P. et al. Nucl. Instr. Meth. Phys. Res. Sect. B, 463 (2020) 437-440.

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