KU LEUVEN

High-resolution Laser Ionization Spectroscopy of Heavy Elements in Supersonic Gas Jets



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Outline

- Motivation for Laser Spectroscopy of Heavy Elements
- In-Gas Laser Ionization and Spectroscopy (IGLIS): Technique
- > Off-line characterization studies
- Plans for IGLIS studies of exotic nuclei



Optical Spectroscopy Actinides



Essential toges: > Laser spectroscopy of fusion evaporation reaction products

- Test and refine n > Low production rates of actinides call for a highly-sensitive and -efficient laser spectroscopy technique
- Improve our und

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Understand the c > High spectral resolution required to <u>resolve hyperfine structure</u>

Map of actinides updated from: P. Campbell, I.D. Moore, M.R. Pearson, Prog. Part. Nucl. Phys. 86 (2015) 127-180

In Gas Laser Ionization and Spectroscopy (IGLIS) In-Cell vs In-Jet Spectroscopy

• Low temperature & low density supersonic gas jets are ideal environments for laser spectroscopy experiments of exotic nuclei

 \rightarrow Reduced Doppler and collisional broadening effects





IGLIS laboratory @ KU Leuven (off-line studies)





High power high rep. dye laser system



<u>R&D on:</u>

RFQ Ion Guides

Laser Spectroscopy of Cu in Atomic Beam Unit

 Narrow-band pulsed dye amplification results in multiple side-band formation Pulsed Dye Amplifier pumped by SLM Laser^Z





High Mach-number Nozzle (M=8.5): Calculations & Manufacturing



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Characterization of local flow parameters: Planar Laser Induced Fluorescence Spectroscopy





Characterization of local flow parameters: Resonance Ionization Spectroscopy

Geometrical scanning lasers to characterize jet parameters



High Mach-number Nozzle: results

- Good agreement between PLIFS and RIS data
- Calculations reproduce fairly well the trend of RIS and PLIFS data
- Discrepancy between experimental curves and calculations can be explained by laser misalignment





In-gas-jet laser ionization and spectroscopy of ^{229m}Th

Only one group has reported the production of a controlled ion beam of ^{229m}Th

- Confirm nuclear structure (nuclear moments) and probe not-yet-observed ^{229m}Th¹⁺
- Produce pure beams of ^{229m}Th



Goal: Determination of $E_{i.s.}$ by VUV spectrometry (149.7 ± 3.1 nm) implanting ^{229m}Th in a transparent crystal





Y. Kudryavtsev et al., NIM B297 (2013) 7

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Outlook: Reach of IGLIS on Actinides





Summary

• Optimization/characterization of IGLIS technique to study products of fusion evaporation reactions is ongoing at KU Leuven (milestones: nozzle, narrow-band laser, RFQ Ion Guides)

 Comparison RIS & PLIFS shows that the former will complementary be used to characterize local flow parameters → Higher efficiency and faster than PLIFS

 IGLIS combines good efficiency and spectral resolution and is well suited for the study of heavy elements → ^{229m}Th@KU Leuven, ^{253,254m,255}No@GSI, S³-LEB@SPIRAL2.....

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