Laser Spectroscopy of the Heaviest Elements at GSI

P. Chhetri1,2, D. Ackermann3, H. Backe4, M. Block4,5, B. Cheal6, Ch. E. Dühmann2,4,5, C. Droese7, J. Even8, R. Ferrer9, F. Giacoppi2,5, S. Götz2,4,5, F. P.- Hessberger3,9, O. Kaleja1,2, J. Khuyagbaatar2,5, P. Kunz10, M. Laatiaoui2,5,9, F. Lautenschläger1,2, W. Lauth3, N. Lecesne5, L. Lens2,4, E. Minaya-Ramirez1, A. K. Mistry2,5, S. Raeder2,5, Th. Walther1, A. Yakuhev2,5, Z. Zhang1

1 TU Darmstadt, 2 GSI, 3 GANIL, 4 Mainz University, 5 HIM, 6 University of Liverpool, 7 University of Greifswald, 8 KVI-CART, 9 KU Leuven, 10 TRIUMF, 11 IPNO, 12 IMP

**Introduction and motivation**

- Explore the atomic structure of transmutation elements (Z>100)
- Search for atomic transitions via 2-step resonance ionization
  - Study of relativistic effects
- Investigation of hyperfine structure
  - Extract nuclear spin and moments
- Study of isotope shifts
  - Extract the changes in mean square charge radii
- Nuclide of interest: 254No (Z=102)
  - Production: 208Pb(46Ca,2n)254No
- Why nobelium?
  - Ground state: [Rn] 5f147s2 1S0
  - Production cross-section: 2 µb

**Experimental setup**

**Radiation Detected Resonance Ionization Spectroscopy (RADRIS)**

- Gas filled stopping cell behind the velocity filter **SHIP @ GSI**

**Principle of the RADRIS technique**

(a) Thermalization in 100 mbar argon gas
(b) Accumulation on tantalum filament
(c) Evaporation from filament
(d) Two step photoionization
(e) Accumulation on silicon detector
(f) Characteristic decay detection

**Results & outlook**

**Measurements on nobelium**

- 1P1 state at 29961.46(4) cm⁻¹
- Overall efficiency for 254No: (6.4 ± 1)%
- Isotopic shift for 252-254No measured
- Hyperfine structure for 253No measured
- A= 734(46) MHz; B= 2815(686) MHz

**First ionization potential (IP) on nobelium:**

- Several high-lying Rydberg states observed in 254No.
- IP extracted from the Rydberg convergence to be 6.6261(1) eV.

**Future measurements**

- Extend the isotope chain of No, e.g. 251No, 255No
- Laser spectroscopy of lawrencium (Lr, Z = 103) and beyond

---

**Work supported by BMFT, HIM and ENSAR**