Resonant Ionization of Atomic Tellurium with Ti:Sapphire Lasers

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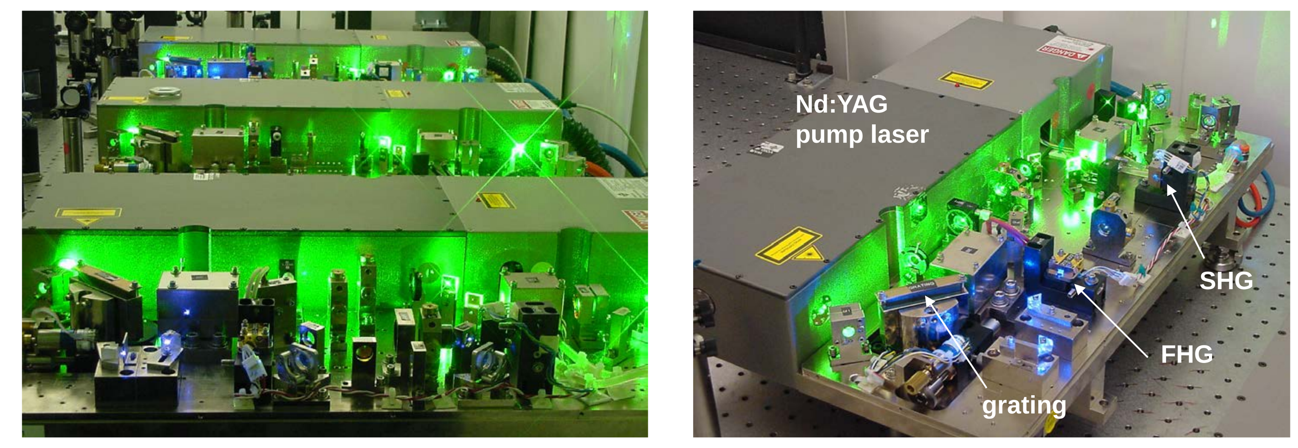
MOTIVATION

- Resonance ionization laser ion sources have become essential tools for the production of isobarically pure radioactive ion beams for nuclear research [1]
- Efficient resonant ionization of beams of atomic tellurium using a combination of Ti:Sapphire and dye lasers has been recently reported [2]. However, the ionization schemes are not applicable to laser ion sources equipped only with Ti:Sapphire lasers
- This study investigates potential resonant ionization schemes of tellurium using only Ti:Sapphire lasers
- The resonant ionization laser ion source (RILIS) at the Oak Ridge National Laboratory (ORNL) is equipped with three tunable Ti:Sapphire lasers and is well suited for this study

[1]. V. N. Fedosseev, Yu Kudryavtsev, V. I. Mishin, Phys. Scr. 85 (2012) 058104.
[2]. T. Day Goodacre, et al., Hyperfine Interact (2017) 238:41.

LASER SYSTEM

Three Ti:Sapphire lasers, three Q-switched, frequency-doubled Nd:YAG pump lasers, and frequency doubling (SHG), tripling (THG), and quadrupling (FHG) units



- Nd:YAG pump lasers: 18-20 W max. power
- Repetition rate: 10 kHz
- Ti:Sapphire laser pulse width: 25 to 30 ns

Figure 1. Photos of the Ti:Sapphire laser system for the RILIS at ORNL.

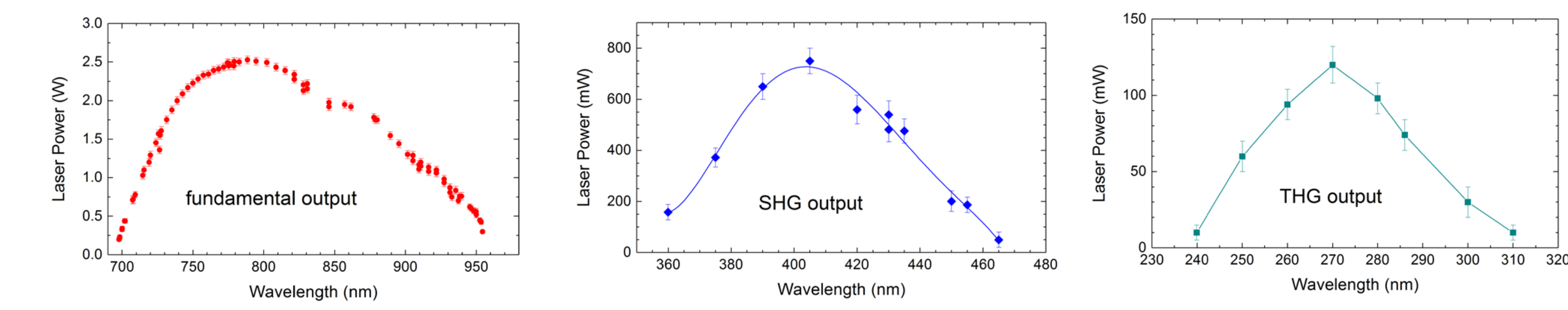


Figure 2. Typical Ti:Sapphire laser power and tuning range of the fundamental, SHG, and THG outputs. The fundamental wavelength is continuously tunable. FHG is available for 208 – 230 nm.

EXPERIMENTAL

- Experiment conducted at the Injector for Radioactive Ion Species (IRIS2)
- IRIS2: an ISOL production station for former Holifield Radioactive Ion Beam Facility (HRIBF). The major components for this study include
  1. Target and ion source (TIS) assembly located on a 60-kV platform
  2. Switching magnet
  3. Mass-separator magnets with a nominal resolving power of 1000 : 1
  4. Faraday cups (FC) to measure the ion beam currents
  5. Vacuum window for laser beam injection

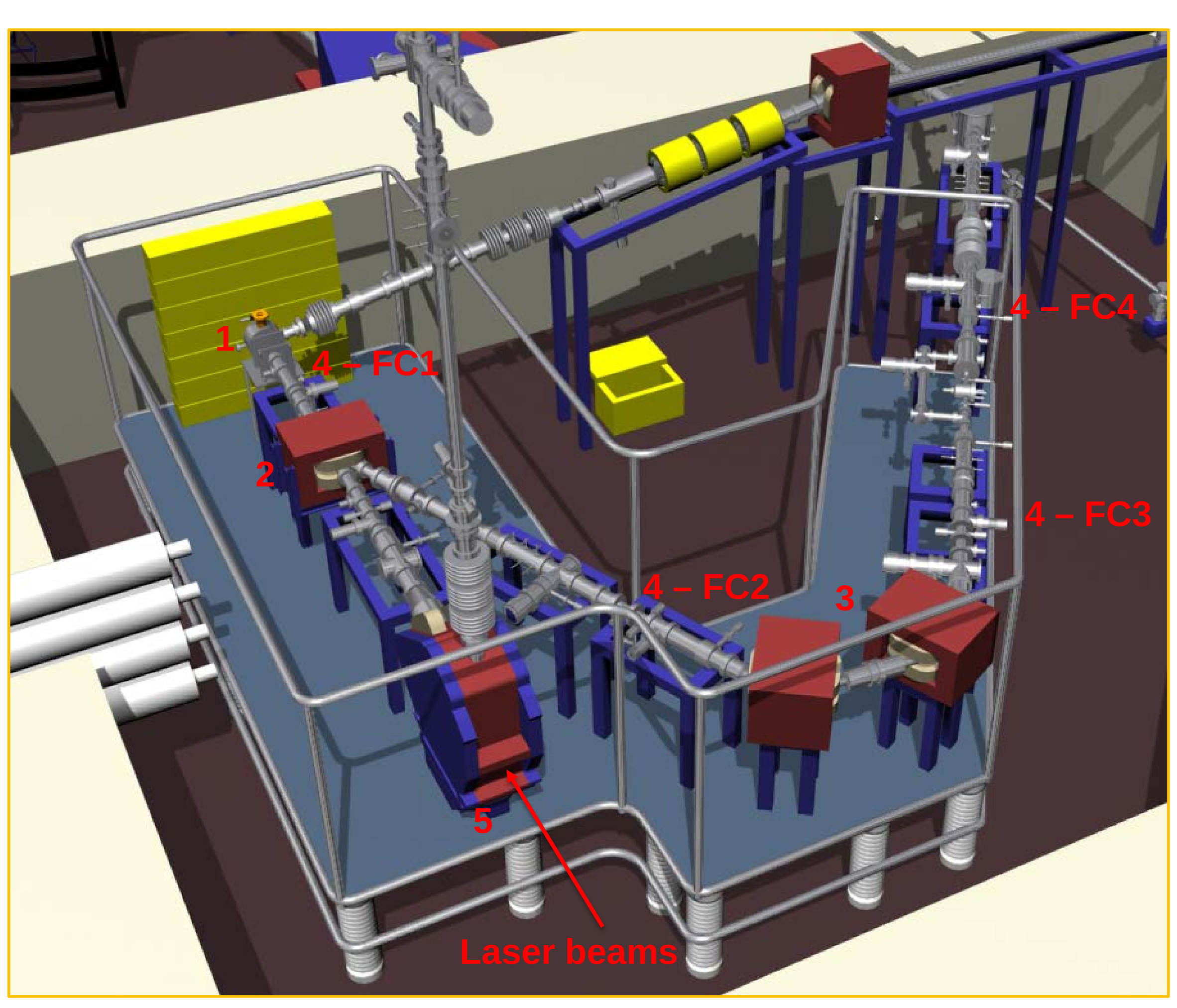


Figure 3. Layout of the IRIS2 platform. Individual elements used for this study are labeled by numbers.

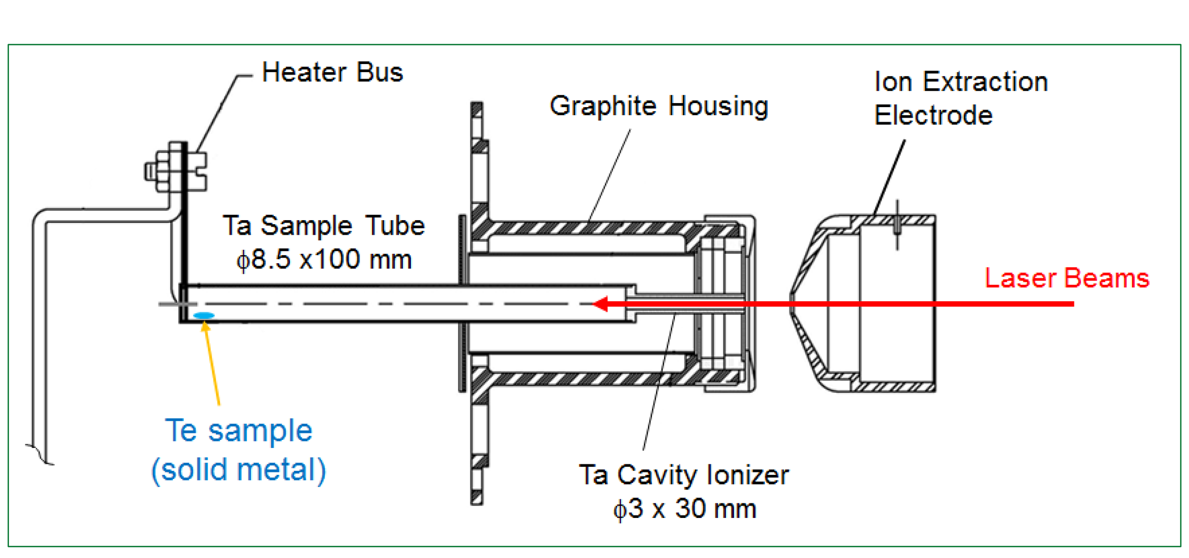
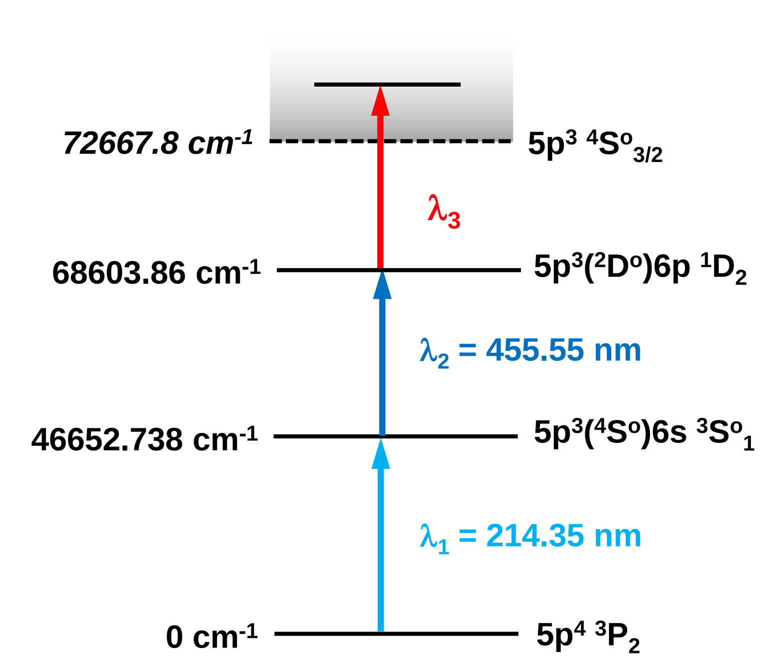


Figure 4. The hot-cavity ion source mounted in IRIS2 TIS enclosure. Solid Te metal sample was placed in the sample tube. The tube and the cavity were resistively heated by an electric current.

- Te sample was heated in the sample tube of the ion source (Fig. 4). The volatile species effused into the hot-cavity ionizer where they were selectively ionized by laser beams. The ions were extracted, trans-ported to the mass separator (3), and the mass-selected ion beam current was measured with a Faraday cup (FC3 or FC4)

RESULTS



- Three-step, three-photon ionization of Te was studied. The laser wavelength for the final excitation (λ_3) was scanned to search for resonant ionization transitions
- Numerous autoionizing and Rydberg states have been observed

Figure 5. A three-step resonant ionization scheme obtained for Te. The first and second excitation steps used frequency-quadrupled (FHG) and frequency-doubled (SHG) photons, respectively. In the third step, the excited Te atoms could be resonantly ionized by near-infrared photons via autoionizing states.

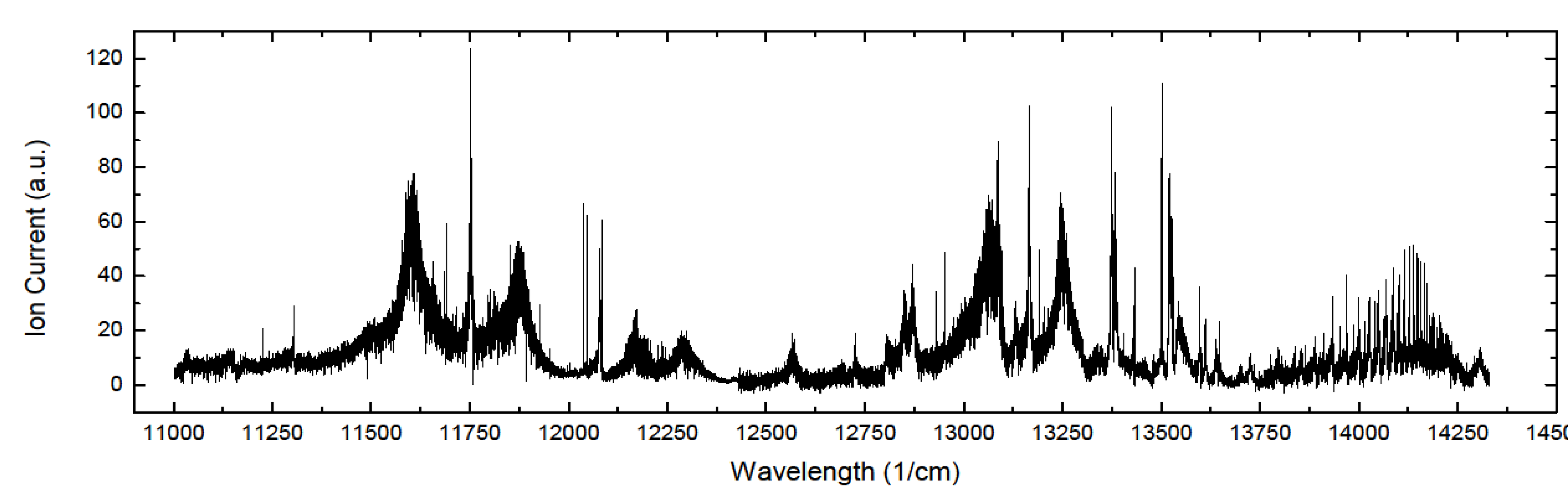


Figure 6. Photoionization spectrum obtained by scanning the third laser wavelength (λ_3), showing numerous autoionizing states and autoionizing Rydberg states.

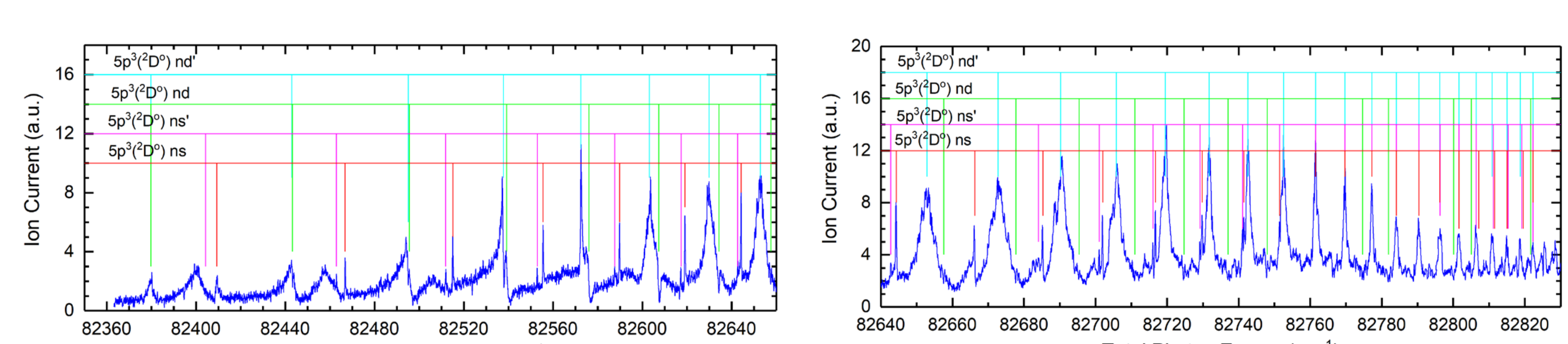


Figure 7. Tentatively assigned autoionizing Rydberg series converging to the $5p^3\ ^2D^o_{3/2}$ state of Te II. Analysis of the spectra is in progress.

CONCLUSION

- Three-step resonant ionization of Te with all Ti:Sapphire lasers is demonstrated
- Analysis of the photoionization spectra is in progress to identify potentially efficient ionization schemes
- Next step: evaluate the efficiency of selected candidate schemes

Acknowledgements

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