RILIS - Status and Developments 2017

ISOLDE Workshop and User’s Meeting

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On behalf of the RILIS team
The RILIS team 2017

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Support from Mainz: Reinhard Heinke, Dominik Studer
A quick reminder

- RILIS: Resonance Ionization Laser Ion Source
- Coupled to surface ion source
- Use intrinsic properties (energy levels) of atom
- ‘Fingerprint’ specific for each element
- Ionization of elements with high (non surface ionizable) ionization potentials
- Enhancement of selectivity (laser ionization vs surface ionization)
RILIS Layout

RILIS laser room

Ti:Sa

Ti:Sa

Ti:Sa intra cavity doubled

F.C.U.

MSS Dye

Sirah Credo Dye

Sirah Credo Dye

F.C.U.

Pi Nd:YAG

Pi Nd:YAG

CB Nd:YVO₄

EW Nd:YAG

Restricted area

Dipole mass separator

Hot cavity + transfer line

Extraction electrode

Total laser beam path ~20 m

Faraday cup

To the experimental hall

F.C.U. : Frequency conversion unit

Prism

Mirror

Telescope

4
Lasers currently used at RILIS

• Dye lasers
  • 2x Credo from Sirah (linewidth ~8GHz)
  • MSS dye laser (linewidth up to 30GHz)
Lasers currently used at RILIS

- **Ti:Sa lasers**
  - 2x **NEW** Z-cavities from Mainz → convenient for intra-cavity doubling (10W pump beam for up to 1.5W of blue with BIBO)
  - 1 standard Z-cavity, „old“ design
  - Linewidth ~5GHz
  - Possibility to exchange 1 cavity with grating Ti:Sa for spectroscopy (linewidth ~1-2GHz)
Lasers currently used at RILIS

- Frequency-doubled DPSS lasers (532nm)
  - 1x Blaze (40W) for non resonant ionization
    - New laser was supposed to be delivered April 2017 → will (hopefully) arrive February 2018
  - 2x Photonics (60W) for Ti:Sa pumping
    - Laser failure: overheating of 1 laser head due to stopped cooling (spare was used for continued operation)
    - Some issues with chillers: 1 pump replacement, 1 needs to be send for refurbishment
  - 1x Edgewave (100W) for dye laser pumping NEW

- IS400-2-G
  - 10 kHz (9 ns), 100 W @ 532 nm
  - Simple operation; better dye laser efficiency and beam quality
  - Easy to transport to ion source (Blaze backup)
  - Objective assessment of degradation of beam quality
  - Better compatibility with commercial dye lasers

- TEM 00, $M^2 = 1.1$
  - Circular, Gaussian beam
Some statistics from the on-line period

• **20** different elements (on-line operation, in-source spectr., TISD): In, Mg, Mn, Al, Bi, Cd, Se, Sm, Ni, Dy, Nd, Ga, Li, Hg, Cu, Mo, Sc, Ti, Si, Te

• **21** separate on-line runs (not included: development)

• **95** days of (on-call) operation (not included: set up & development time)

> **50%** of ISOLDE beams in 2017
Laser ionization scheme development

→ Mostly „parasitic“ development in between or during runs
→ Effort towards more 2-step and Ti:Sa based schemes for reduced maintenance
Beam development

Scandium

Ionization scheme developed in Mainz was tested
First, long-awaited, on-line yields of Sc measured
"Sc beams now available at ISOLDE!"

6 changes in 4 days!
Ti → Sc → Dy → Sc → Se → Dy → Ni
Beam development

**Tellurium:** Scheme used first time for yield tests \(\rightarrow\) can now be provided for users

![Tellurium Energy Levels Diagram]

**Molybdenum:** Scheme used on-line for first time in combination with molecular break up (see talk by J. Balloff)

![Molybdenum Energy Levels Diagram]
Other activities: work at ISOLDE Off-Line 1 – VAD(L)IS

Continued developments on VAD(L)IS ion source (off-line and on-line)

→ Simulations with VSim by Y. Martinez Palenzuela for better extraction of laser ionized particles

T. Day Goodacre et al., NIM B 376, 39 (2016)
Other activities: work at ISOLDE Off-Line 1 – VAD(L)IS

- New design with variable extraction voltage improves laser ion extraction
- Demonstrated off-line with Ga
- Demonstrated on-line (last week) with Mg: **factor 3 extraction efficiency improvement** when voltage was adjusted!

Credit: Y. Martinez Palenzuela
Other activities: work at ISOLDE Off-Line 1 – Laser installation

• Laser installation for Ga tests: Edgewave pump laser + dye laser (2-step scheme)

• Inconvenient: requires delay line for pump beam & set up of (very old) dye laser

• Laser installation in Off-Line 1 has been dismantled
  → to be replaced with Ti:Sa laser set up for LIST development in 2018
  → Convenient scheme for Sm requires only 1 Ti:Sa laser + pump
Other activities: Ti:Sa laser set up in LARIS lab

• LARIS converted temporarily into negative ion source test facility for target group
• Master thesis work of David Leimbach (poster yesterday)
• Ti:Sa laser set up for off-line photo detachment tests of iodine
• Set up & tests are happening this week
Other activities: Towards (really) narrow band RILIS operation

- Efforts towards high resolution spectroscopy
- Aim: Doppler-free two-photon excitation in-source
- Demonstrated successfully at RISIKO Mainz off-line separator for Rb

\[(\omega_1 + \omega_D) + (\omega_1 - \omega_D) = 2\omega_1\]

- FWHM = 72.8 MHz
  - Outer peaks 68 MHz apart, but \(2\rightarrow1\) transition weakest one, so more likely width is around <52 MHz (\(2\rightarrow2\) also weak compared to \(2\rightarrow3,4\))

- FWHM = 69 MHz
  - Outer peaks 39 MHz apart
Other activities: Towards (really) narrow band RILIS operation

- Efforts towards high resolution spectroscopy
- Aim: Doppler-free two-photon excitation in-source
- **Problem:** Current laser set up does not allow for linewidths < 800MHz

**Solution 1:**
Use seeded Ti:Sa ring cavity
- New fiber has been put in place between RILIS and CRIS labs
- Minituarized design of ring cavity, developed in Jyväskylä and Mainz
- Use M²-laser for seeding ring cavity in RILIS
Other activities: Towards (really) narrow band RILIS operation

- Efforts towards high resolution spectroscopy
- Aim: Doppler-free two-photon excitation in-source
- **Problem:** Current laser set up does not allow for linewidths < 800MHz

**Solution 2:**
Use Pulsed Dye Amplifier (PDA)
- Two dye cells for amplification
- Test set up in CRIS lab
- Old Edgewave laser for pumping
- Amplification of Matisse CW laser
Other activities: Off-Line2 & MEDICIS

• New laser installations

→ Off-line 2:
  • Testbench for laser scheme ionization development
  • Tests for molecular break up in the cooler
  • Continued tests for VAD(L)IS & LIST

→ MEDICIS:
  • Beginning of installation of Laser Ion Source
  • First things first: Transform the available room into a lab
  • Start purchase of lasers and optics for equipping the lab
Conclusion

• 4 new schemes (Mo, Se, Ti, Sm)

• 2 new beams (Sc, Te)

• On-going ion source developments for better RILIS efficiency and suppression of contaminants (VADLIS & LIST)

• New approaches to in-source high-resolution spectroscopy
  → first tests done in Mainz
  → new lasers for RILIS in collaboration with CRIS & Mainz

• New laser installations planned for Off-Line 2 and MEDICIS
Thank you for your attention!