Beam Cooling and Laser Spectroscopy (BECOLA) Project at NSCL
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Why Laser Experiments at NSCL?

Thermalized fast rare isotope beams are available at NSCL by gas stopping. Good quality, low energy beams opens up a new range of laser spectroscopy experiments, which will complement studies at ISOL facilities.

Objective is to determine the fundamental properties of nuclides: $I$, $\mu_B$, $Q$, $\Delta <^2\gamma>$. Two highly sensitive techniques will be used so that nuclei with $\geq 10^7$/s production rate can be accessible: laser spectroscopy with cooled/bunched beam and $\beta$-NMR technique with laser polarization.

Many laser spectroscopy experiments have been performed at ISOL type facilities. However refractory elements are difficult to extract from ISOL targets.

Optical Pumping + $\beta$NMR

A large nuclear polarization produced by the laser pumping technique is combined with $\beta$-NMR technique for highly sensitive measurements. $\geq 10^7$/s ion rate can be used with.

Circularly polarized light is used to populate ground $m_f = 2$ state, where polarization is the maximum.

Cooled/Bunched Beam + Laser Spectroscopy

Cooled/bunched beam produced by a gas filled RFQ ion trap can significantly increase the signal to noise ratio (S/N) in laser spectroscopy measurements. $\geq 10^7$/s ion rate can be used.

Advanced Cooler/Buncher

New electrode structure for RFQ ion trap was simulated (SIMION 8.0) for higher frequency and voltage. This is to achieve better emittance of extracted beams as well as better confinement of ions, which helps to have short bunches and further increase sensitivity in photon counting measurements.

Low Energy Exp. Area

- DPSS laser @ 523 nm, 15 W
- Ti:S laser: 700–1000 nm
- Frequency doubler 350–500 nm
- Precise wavelength meter for a feedback loop for long term laser stability
- Electro-optic phase modulators will be used to cover broadened absorption line width due to multiple scattering with Na vapor for neutralization.

Results of simulation indicate an acceptance of 60 nm mm-mrad for a 60 keV beam, and that delivery of ion pulses with transverse emittance of 1 n mm-mrad and longitudinal emittance of 1.5 eV-μs are achievable.

A prototype is being tested for higher frequency and voltage.

A beam from the gas stopping system can go one way or another into two beam lines after the RFQ ion trap for optical pumping + $\beta$NMR and laser spectroscopy with cooled/bunched beams. Laser light will be collinearly overlapping with the ion/atom beams. The second beam line will allow future developments for low rate laser spectroscopy exp..

BECOLA Layout @ NSCL

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Optical Pumping + $\beta$NMR

- design completed and being manufactured at NSCL
- A 60 keV beam from cooler/buncher
- may be neutralized by charge exchange reaction with Na vapor
- re-circulating Na-vapor system
- very low Na leakage rate
- weak magnetic field along the beam line to keep the polarization direction
- photon counting system will be installed to detect de-exciting photons after laser excitation

Polarizer Beam Line

- DPSS laser @ 523 nm, 15 W
- Ti:S laser: 700–1000 nm
- Frequency doubler 350–500 nm
- Precise wavelength meter for a feedback loop for long term laser stability
- Electro-optic phase modulators will be used to cover broadened absorption line width due to multiple scattering with Na vapor for neutralization.

Thanks: C. D. P. Levy @ TRIUMF

The NSCL is funded in part by the National Science Foundation and Michigan State University.

NSCL

- Beam line operational with off line ion source: ~mid/late 2010

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Institute for Nuclear Studies

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