Towards laserspectroscopy at CRYRING@ESR

Polarization of ion beams by optical pumping

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Motivation

Polarized ion beams of heavy elements in storage rings are of great interest for example on parity non-conservation experiments on He-like ions [1, 2]. Even polarized beams of protons, antiprotons and muons have been established, this is pending for heavy ions. One issue is polarizing the beam in a reasonable time. Using circularly polarized σ^+-light one can populate the atomic substate with the highest magnetic quantum number (or the lowest by using σ^--light).

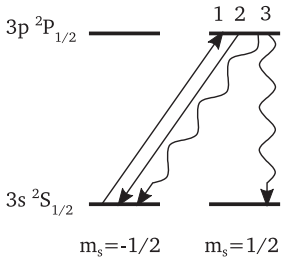
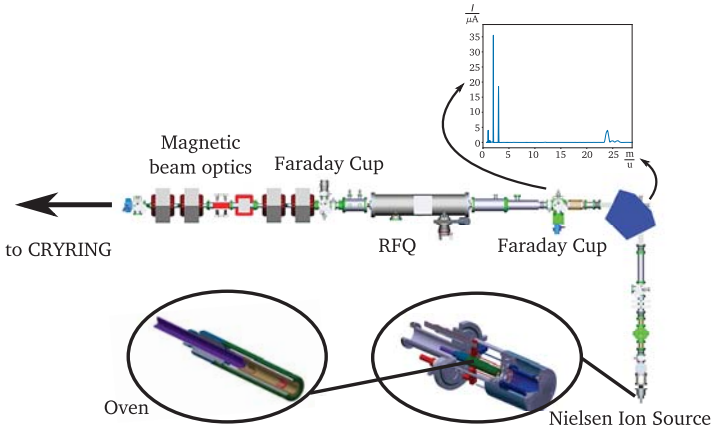
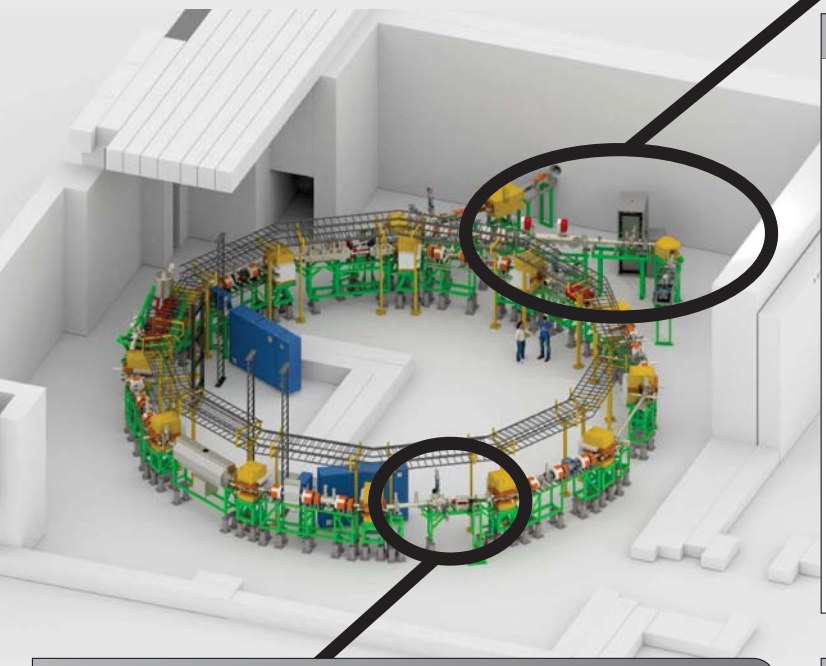


Figure 1: Polarization scheme of $^{24}Mg^+$.

To proof the principle, we want do investigate whether a induced polarization of the electron shell will be maintained after the revolution in a storage ring.

$^{24}Mg^+$-production





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- Magnetic rigidity of $1,44$ Tm leads to ion energies of about 4 MeV in case of $^{24}Mg^+$.
- Circumference of 54 m fitting to the second harmonic of ESR. The highest achievable energy of $^{24}Mg^+$ leads to a frequency of 107 kHz.

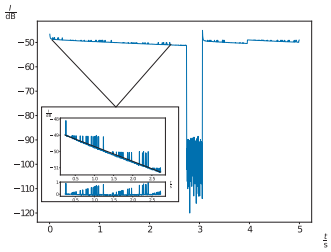
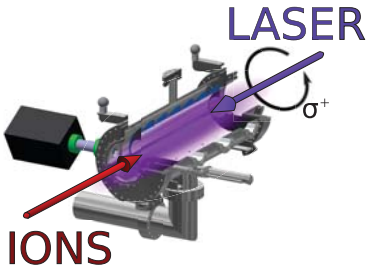


Figure 2: Lifetime-Measurement of $^{24}Mg^+$.

- Acceleration and bunching has been tested successfully during the last beamtime in March for $^{40}Ar^+$ as well as $^{24}Mg^+$.
- Lifetime of Mg was determined to be $9,53$ s at $1,67$ $\frac{\text{keV}}{\text{u}}$ (s. fig. 2).
- Electron-cooler leads to thermal energies of $k_B\,T_\perp < 1,5$ meV for transversal motion and $k_B\,T_\parallel = 0,05$ meV respectively [3].

Detection region and DAQ

- The elliptical mirror system consisting of MIRO3-foil leads to a high reflectivity in the UV-range and thus for the D1 transition of $^{24}Mg^+$.
- Saphire windows to provide high transmission to PMT's sitting on the windows.



- Time resolution down to 10 ns with a FPGA based PXI-system will be possible [4].
- Data acquisition will be adapted to ion-bunches to provide a high Signal-to-noise ratio.
- Maintaining flourescence signal will indicate a successfull polarization of the ion beam.

Outlook

- Analysis of the measured Mg-beam emittance (s. fig. 3).
- Adaption of TILDA to prereqisits of CRYRING@ESR.
- Measurement of laser scattered light.
- First fluorescence measurement.

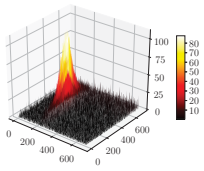


Figure 3: Intensity of $^{24}Mg^+$ at injection beam line diagnostic.

References

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[4] C. Gorges et al., Hyperfine Interactions **238**, 1 (2017).