Journal of Physics: Conference Series **635** (2015) 022093 doi:10.1088/1742-6596/635/2/022093

Laser spectroscopy on lithium-like ions at the HESR

Rodolfo M. Sánchez Alarcón∗ [1]

∗ GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstr. 1, 64291 Darmstadt, Germany

Synopsis Possibilities of studying D1 and D2 transitions in lithium-like ions by laser spectroscopy at the HESR at FAIR are presently being considered. First experiments could already be performed using conventional lasers to excite these transitions in medium-Z lithium-like ions. Hyperfine structure and isotope shift could be studied and nuclear moments and charge radii being extracted. However, challenges connected with these experiments will have to be resolved first.

One of the facilities of the upcoming FAIR project in Darmstadt is the High-Energy Storage Ring (HESR). In this ring, ion beams will be stored and cooled at relativistic energies with γ-values ranging from 2 to 6 [1]. This opens up opportunities of performing laser spectroscopy to effectively excite high-energy transitions in highly charged ions. In combination with the Doppler blue-shift in counter-propagating excitation, especially the $1s^2\ 2s\ ^2\mathrm{S}_{1/2} \rightarrow 1s^2\ 2p\ ^2\mathrm{P}_{1/2}$ (D1) and $1s^2\ 2s\ ^2\mathrm{S}_{1/2} \rightarrow 1s^2\ 2p\ ^2\mathrm{P}_{3/2}$ (D2) transitions in medium-Z lithium-like ions are accessible. Transitions between 20 eV and 60 eV [2] can be already reached with 5.5 eV photons, produced with off-the-shelf frequency-doubled cw or pulsed laser systems.

The theoretical values for the transition frequencies given in [2] do not include radiative corrections, therefore the experimental determination of these lines can already trigger more precise calculations including QED contributions, which have already been evualuated for some systems [3, 4]. If radioactive lithium-like ions are injected into the HESR, isotope shift measurements might provide information on their nuclear charge radii. For ions with nonvanishing nuclear spin I, hyperfine spectroscopy will provide access to nuclear magnetic and electric quadrupole moments (only D2) of these nuclei. The three-electron structure of these ions will have less systematic uncertainties from the calculation of hyperfine fields and might therefore serve as calibration data for studies on more exotic isotopes.

However fluorescence detection represents a challenge with these highly relativistic beams. To detect the fluorescence that is preferably emitted in a narrow cone in forward direction, a suitable detector has to be built and implemented into the beamline under ultra-high vacuum conditions. This Doppler-shifted fluorescence will be emitted with energies ranging between 75 eV and 750 eV under angles smaller than 5° with respect to the ion beam direction. Moreover, there is limited space in the HESR tunnel as well as in the beamline to install the laser setup and the detector, respectively.

References

[1] Th. Stöhlker *et al* 2014 *Hyperfine Interact.* **227** 45.

[2] W. R. Johnson *et al* 1996 *Atom. Data Nucl. Data* **64** 279.

[3] Y. S. Kozhedub *et al* 2010 *Phys. Rev. A* **81** 042513.

[4] J. Sapirstein and K. T. Cheng 2011 *Phys. Rev. A* **83** 012504.

[1]E-mail: R.Sanchez@gsi.de