Towards laser-controlled generation of hydrogen-like ions in Rydberg states

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Synopsis Experiments are being performed at the National Institute of Standards and Technology investigating the laser-controlled generation of hydrogen-like ions in Rydberg states, starting from fully-stripped neon ions isolated at low energy in a Penning trap. Laser spectroscopy on transitions between Rydberg states of these ions will allow for precision measurements of fundamental constants.

We report on the progress being made towards the goal of creating one-electron highly charged ions (HCIs) in high-angular-momentum Rydberg states. This work is motivated by the special properties of such ions that have been shown to be advantageous for precision measurements of fundamental constants [1]. In particular, such a system can provide an independent measurement for the Rydberg constant that is free of nuclear size effects, thereby potentially adding more information to resolve the proton radius puzzle [2].

The electron beam ion trap (EBIT) at the National Institute of Standards and Technology (NIST) is used to produce fully stripped neon ions (Ne^{10+}). These bare nuclei are extracted via a beamline from the EBIT into a second apparatus where they are captured at low energy in a unitary Penning trap [3]. The second apparatus has a cross-beam configuration, with a perpendicular beam of laser-excited Rb atoms intersecting the ion beam at the Penning trap. While stored in the trap, the ions can interact with the Rb and, through charge exchange interactions, the bare nuclei can capture electrons from the Rb, as shown in Figure 1.

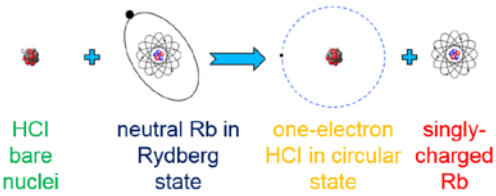

Figure 1. Schematic of the creation of hydrogen-like HCIs in high-angular-momentum states by charge exchange with Rydberg-state Rb.

The charge states of the stored ions are analyzed by dumping the ions from the trap to a time-of-flight (TOF) detector [3]. To search for enhanced electron capture due to the laser excitation, initial studies compare the charge exchange rates in the TOF data for ground-state Rb and for laser-excited Rb.

References

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