# Spectroscopy of Highly Charged Ions Isolated in Compact Penning Traps


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**Abstract.** Unitary-architecture Penning traps, built around rare-earth NdFeB permanent magnets, provide a very compact and well-controlled environment to isolate highly-charged ions (HCI) for spectroscopy and for experiments with exotic states. Following charge-state selection and careful slowing, ions extracted from an electron beam ion trap (EBIT) source are captured in a unitary Penning trap with the resulting thermal energy reduced by a factor of order one hundred, compared to temperatures typically found in an EBIT. HCIs are confined in the unitary traps with storage lifetimes exceeding one second for a room-temperature apparatus, sufficiently long for a variety of ongoing and planned investigations of interest to astrophysics, plasma diagnostics, and fundamental metrology. Holes positioned along the trap mid-plane provide optical access for light collection and future laser spectroscopy of trapped HCI. As a first demonstration, radiative lifetimes of metastable excited states are measured by detecting visible fluorescence emitted by trapped B-like Ar XIV (441 nm, $2p\ ^2P_{3/2} \rightarrow 2p\ ^2P_{1/2}$) and K-like Kr XVIII (637 nm, $3d\ ^2D_{5/2} \rightarrow 3d\ ^2D_{3/2}$). A second apparatus, currently under construction, incorporates an electron gun along with unitary NdFeB structures to form a room-temperature ion source, an extraction beamline, and a compact ion trap to isolate low-Z HCIs. A beam of Rydberg rubidium atoms, also under development, is designed for charge exchange with trapped bare nuclei. An initial goal is the production of hydrogen-like ions in Rydberg states of high angular momentum, an attractive system for precision metrology and tests of atomic structure theory.