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Precision electron collision spectroscopy of highly charged ions

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Collisions between highly charged ions and electrons in merged electron beams have been introduced as a precision tool for determining atomic properties, applying ion storage rings both at lower and at high ion beam energy. Photorecombination in these collisions can be resonant, as the incident electron is captured in a bound quantum state while the target - a few-electron highly charged ion - is excited. Hence, the resonances probe the excitations of few-electron ions with high energy resolution. In precision electron collision spectroscopy at ion storage rings, resonance energies in the total photorecombination cross section (dielectronic recombination) are measured by precisely varying the electron impact energy. At lower ion energies, in the storage ring TSR, Heidelberg, resonances at collision energies down to less than 10 meV were resolved for medium-heavy ions, finding the 2s-2p excitation energies in Li-like scandium (Z=21) at the highest absolute precision so far realized for this transition in any highly charged ion. Moreover, the hyperfine splitting of the electron recombination resonances is resolved for this nucleus. While TSR obtained highest resolution using a photocathode electron source, the ESR at GSI has addressed much heavier Li-like systems with a similar technique, extracting nuclear charge radii from dielectronic recombination energies of three-electron Nd ions (Z=60) and very recently obtaining data of this type even for Li-like uranium nuclides. The technique and the results will be reviewed. Also the perspective of using systems with a larger electron number as precision probes for ionic-core or even nuclear excitations will be discussed. In recent studies at TSR, the use of the technique also for Be-like and B-like ions was investigated (Z=32 and 26, respectively). With a precise theoretical understanding, suitable low-energy photorecombination resonances would become available for a wider range of elements than for Li-like ions, while the challenges for atomic structure calculations increase.

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