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Nuclear Effects in Atomic Lifetimes: Studied with Be-like ions at Storage Rings and EBITs

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Be-like ions are sources of forbidden emission lines which are relevant for the information on astrophysical plasmas. We propose to study the lifetimes of metastable states, and the influence of nuclear spin on it, in Be-like ions along the isoelectronic series, through electron-ion collision processes and through laser excitation. The radiative decay of the 1s^2 2s2p(^3P_0) first excited state is strongly forbidden and as a consequence, this state has very long lifetime in ions along the Be-like isoelectronic sequence [1]. A nuclear spin, if present, mixes a small amount of (^1P_1) character into the 1s^2 2s2p(^3P_0) state, which opens a weak radiative decay mode of the metastable state. Thus in the presence of a nuclear spin, the lifetime becomes on the order of seconds and it is accessible for storage ring experiments [2]. Because the dielectronic recombination (DR) spectrum of the ground state and metastable ions is different, recombination measurements allow the selective access to ions in metastable and ground state.
At storage rings ions can be observed from μs to hours, and DR offers a fast and efficient way of monitoring the amount of metastable fractions and thus these lifetimes even for radioactive ion beams as they will become available in NESR of FAIR. At first, we plan to test the theoretical description of nuclear effects on the electronic structure with experimental lifetimes at stable isotopes. We expect to apply this knowledge on nuclear properties of radioactive ions at FAIR. Additionally, in the experiments, different charge breeding techniques and collision with electrons and/or high density gas jet targets could prove to be useful for populating the (^3P_0) metastable state and for production of ion beams with enhanced metastable content.
At Electron Beam Ion Traps (EBIT), laser spectroscopy of the trapped ions will provide information about level separation and lifetimes of the (^3P_j) states. Also, in Be-like ions, an exotic recombination channel proceeds through the simultaneous excitation of both 2s core electrons during the attachment of the free electron[3]. This reaction channel termed tri-electronic recombination, gives strong contributions to the recombination spectra of Be-like ions. Due to the strong correlation of the two excited electrons, this process is relevant for the description of electron-electron interaction. In case of the highly charged Be-like ions created in the EBIT, the detected photons will reveal information about the radiative stabilization paths of the triply excited states through which TR takes place. The description of the involved triply excited states is challenging for theory and the obtained experimental results will benchmark the calculations.

References

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