Mixed state ($1s^2$, $1s2s\ ^3S$) He-like Ions In Collisions With Gas Targets - Search For The Elusive Cascades

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Cascade feeding has been recognized as a significant process that can affect the production and decay dynamics of collisionally populated states in beam-foil spectroscopy studies [1]. Recently, interest has focused on the state selective cascade feeding mechanism, proposed as a candidate to explain the enhanced population of the $1s2s2p\ ^4P$ state reported for collisions of few MeV/u He-like ions with He targets [2,3]. He-like ion beams provided by tandem accelerators are typically delivered in mixed ($1s^2$, $1s2s\ ^3S$) ionic state. The $1s2s2p\ ^4P$ excited state is then primarily formed by electron transfer to the 2p state of the $1s2s\ ^3S$ long-lived beam component. The metastability of the $1s2s2p\ ^4P$ state allows for the consideration of a possible population enhancement driven by radiative decay from higher lying quartet states. Electron transfer to the 2p state also leads to the formation of the $1s2s2p\ ^2P$ state. However, the latter is not expected to be enhanced by radiative cascade feeding from higher lying doublet states due to their very small fluorescence yield along the cascade ladder. These state selective cascade feeding effects should be observable in the ratio of cross sections for the production of ^4P and ^2P states, $R_m = \sigma(1s2s2p\ ^4P) / \sigma(1s2s2p\ ^2P)$, as deviations from its spin statistics value of 2 [4].

Towards such an investigation we have recently developed: (i) a new method for separating the contributions from the $1s^2$ and $1s2s\ ^3S$ components of the mixed ($1s^2$, $1s2s\ ^3S$) beam [5] and (ii) an approach for the determination of the detection efficiency of Auger metastable states based on Monte Carlo-type simulations within the SIMION ion optics package [6], which were recently verified experimentally [7]. Based on these, we report on our new data on the KLL Auger electron spectra obtained in collisions of 6, 9, 12 and 15 MeV C^{4+}($1s^2$, $1s2s\ ^3S$) with H_2, He, Ne and Ar targets. These measurements were performed at the 5.5 MV tandem accelerator of the NCSR "Demokritos" within the APAPES [8] project utilizing our zero-degree Auger projectile spectroscopy apparatus. Surprisingly, our results show R_m to be close to its spin statistics value of 2, contrary to earlier experimental [2] and theoretical [9] reports that supported much higher values. Since this behavior is currently not well understood, we focus on the reexamination of the proposed cascade feeding mechanism for these collision energies, as well as on other possible processes that could reduce the cascades.

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