Two–electron capture by fast highly charged ions with emission of a single photon

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Two electron capture with emission of a single photon (TESP) is a radiative process in which two electrons are captured into a bound state of an ion with emission of single photon. This process has recently been studied both experimentally [1] and theoretically [2, 3, 4] in situations in which fast heavy and highly charged ions, of charge Z_P, collide with light targets in which electrons are relatively weakly bound (in a field of charge Z_T). In such circumstances, $Z_P \gg Z_T$, the TESP process has been viewed [1, 3, 4] as the time reversal of the double ionization process by absorption of a high energy photon, but in the specific kinematics in which both electrons are leaving the atom with the same momentum, and neglecting the dependence of the TESP process on the initial state electron distribution (probability to find the two electrons in the reaction region).

We study the TESP process for fast (velocity V) highly charged ions in the situation $Z_P \gg Z_T$. Starting from the realistic situation in which the two electrons are bound in the field of a nucleus of charge Z_T, and taking $Z_P \gg Z_T$ and $V \gg Z_P\alpha$ we are able to factorize out M_T, the dependence of the TESP matrix matrix element on the distribution of the initial state electrons (dependence on Z_T), while the remaining factor M_P can be treated as a time reversal of double ionization photoabsorption in a kinematics in which the two electrons leave the atom with nearly the same momentum.

In treating M_P we apply time reversal and calculate the matrix element for double ionization M_{DI} using our general nonrelativistic approach [5], in which the dominant contribution to the matrix element for ionization by photoabsorption is associated with singularities of the Coulombic potential in specific kinematics. Using this procedure we are able to distinguish contributions determined by the e–e singularity and by the e–N singularity, and to discuss separately their energy dependence and Z_P dependence. In addition to the Z_P dependence, which is common for the double ionization and (through time reversal) for the double capture mechanisms, we find a very strong Z_T^3 dependence of the TESP processes (unlike single electron capture, which does not have such strong Z_T dependence), which implies that only relatively strongly bound target electrons are involved in the two electron capture.

[1] A. Warczak *et al.*, Nucl. Instrum. Methods B **98,** 303 (1995).
[2] J. E. Miraglia and M. S. Gravielle, XVI ICPEAC, Brighton 1987, Book of Abstracts, p. 517.
[3] V. L. Yakhontov and M. Ya. Amusia, Phys. Lett. A **221,** 328 (1996).
[4] V. L. Yakhontov and M. Ya. Amusia, Phys. Rev. A **55,** 1952 (1997).
[5] T. Surić, E. G. Drukarev, and R. H. Pratt, to be published.