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Kinetic Energy Distributions of Muonic and Pionic Hydrogen Atoms

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The exotic hydrogen-like atoms are formed in a highly excited atomic states after slowing down and Coulomb capture of negatively charged particles (muon, pion, etc.) in hydrogen media. The further evolution of their initial distribution in quantum numbers and kinetic energy depends on the complicated interplay of the radiative transitions and collisional-induced processes during the so-called atomic cascade.

In this report we present the kinetic energy distributions of muonic and pionic hydrogen atom at the instant of the radiative transitions from np-states to the ground state or the charge-exchange reaction (in the case of pionic hydrogen). These distributions were calculated within the improved version of the extended cascade model at different values of the target density. In this model, we used the new differential and integral cross sections for collisional transitions between different atom states with the values of the principal quantum number $n = 2 - 12$ calculated in the framework of the close-coupling approach.

The initial n, l, E-distributions are taken into account and in this cascade model lead to a very good agreement with the experimental data at very low target density. The results of the present cascade calculations allow us for the first time to explain the observed kinetic energy distribution of pionic atoms at the instant of the pion charge-exchange reaction. In particular, our results explain the high-energy components around 105 eV and 209 eV (due to Coulomb transitions 5-3 and 3-2, respectively) and are in a very good agreement with the experimental weights of these components.

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