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Improved study of the collisional quenching of the pionic helium long-lived states

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The existence of long-lived states in exotic helium atoms (πˆ-,Kˆ-,p¯-Heˆ+) predicted by Kondo [1] about 60 years ago made it possible to conduct various series of unique high-precision laser spectroscopic experiments: thus, direct observations of E1-transitions between anti-proton helium states and M1-transitions between its superfine structure levels [2-4] were performed. Then similar experiments were continued on pionic helium atoms, where it was possible to observe transitions between atomic states [5,6]. The purpose of the conducted experiments is to obtain highly accurate fundamental characteristics of quantum objects: the antiproton magnetic moment, and upper limits on laboratory constraints on the muon antineutrino mass.
To interpret the obtained results, many theoretical questions arise; in particular, the very possibility of carrying out high-precision laser spectroscopic experiments with hadronic helium atoms depends on the destruction rate of metastable states during collisions in a medium. The rate of Stark collisional quenching of highly excited states is the highest. We use the Potential Energy Surface (PES) of three-electron πˆ- Heˆ+-He system in which the three electrons move in the field of three heavy particles (two α-particles and πˆ-) to obtain an interaction between the colliding systems and then the rates. The PES was calculated by Unrestricted Hartree-Fock (UHF) method in Dunning's aug-cc-pV5Z basis with counterpoise correction and with account of electron-electron correlations by Moller-Plesset (MP2) method.
The numerical calculations of PES and then the numerical solution of the system of close-coupling equations are improved, especially in the region of small distances between the colliding πˆ- Heˆ+-He subsystems, where some peculiarities and unusial behavior arise due to the strog interchannel interaction, and whose contribution to the rates of collisional transitions is significant. The cross sections for these transitions are systematically calculated, and the obtained results are compared to the experimental ones.

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The speaker is a student or young scientist

No

Section

1. Nuclear structure: theory and experiment

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