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Interaction of antiprotonic helium with medium atoms and collisional transitions between HFS $(\bar{p}\mathrm{He}^+)$ states

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Collisions of metastable antiprotonic helium atoms with the medium atoms induce, inter alia, transitions between hyperfine structure (HFS) states, as well as shifts and broadening of microwave M1 spectral lines. These effects were studied in the experiments with the low-temperature ^{4}He [1,2] and ^{3}He [3] targets, and were considered in the framework of the model interaction between (pHe^+) and He [4,5]. In this work, interaction between thermalized antiprotonic $(\mathrm{p}^4\mathrm{He}^+)$ atom and ordinary ^{4}He atom is described by an ab initio potential energy surface (PES) calculated in the framework of unrestricted Hartree-Fock method with account for electron correlations in the second-order perturbation theory (MP2). With this PES, the system of close-coupling equations for HFS channels is solved numerically. Cross sections and transition rates, shifts and broadening of M1 spectral lines are calculated. They are used to obtain a numerical solution of the master equation that determines the time evolution of the HFS-states density matrix. The results are compared with the experimental data and with the model calculation.

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