Theoretical study of Auger dominant metastable states in antiprotonic helium atoms.

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It is known that the problem of getting an accurate solution for the Auger dominant states in the antiprotonic helium is a pretty difficult task due to very narrow widths of these states and different scales for antiproton and electron orbitals. So, it was conceivable that the Complex Coordinate Rotation (CCR) method could not be used for such calculations. Recently, we have managed to find a proper configuration of the variational wave function that

state	Δl	E_{nr}	$\Gamma/2$
(39,34)	3	$-2.77101156918(4)$	$0.993(4)\cdot 10^{-8}$
(38,34)	3	$-2.836524596427(4)$	$1.626(4)\cdot 10^{-9}$
(38,33)	2	$-2.847324042(3)$	$3.714(3)\cdot 10^{-6}$
(37,33)	3	$-2.922449847(1)$	$5.09(1)\cdot 10^{-7}$
(36,33)	3	$-3.00797908793(2)$	$2.92(2)\cdot 10^{-9}$
(32,31)	4	$-3.50763503077540(4)$	$0.51(4)\cdot 10^{-12}$

Table 1: Multipolarities of the Auger transition Δl, nonrelativistic energies E_{nr} (in a.u.), Auger widths Γ (in a.u.) for the Auger dominant states of $^4\mathrm{He}^+\bar{p}$ atom.

enables to get accurate solutions for the rotated Hamiltonian. It includes four sets of nonlinear parameters which correspond to different contributions to the wave function of a resonant state. Namely, from excited electron intermediate states, an electron continuum state, and two sets are required for precise determination of the bound part of the wave function. Results are presented in Table 1. An accurate solution for these states is essential for comparison with recent experimental results [1], since so far almost all experimentally observed transitions have Auger dominant state as a daughter state. More over, in a forthcoming high-resolution two-photon experiment [2] which is aimed to measure the $(38,35) \to (36,33)$ transition, the daughter state is Auger dominant and detailed theoretical description requires consideration of a resonant nature of the $(36,33)$ state to enable precise theoretical predictions for this transition.

References

[1] M. Hori, J. Eades, R.S. Hayano, T. Ishikawa, J. Sakaguchi, E. Widmann, H. Yamaguchi, H.A. Torii, B. Juhász, D. Horváth, and T. Yamazaki, Phys. Rev. Lett. **87**, 193401 (2001).

[2] ASACUSA status report, CERN/SPSC 2002-002, SPSC/M-647, 2002.