A complex-rotation calculation for resonances in Ps^- embedded in Debye plasmas*

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With the recent developments in laser plasmas produced by laser fusion in laboratories [1], and the continued interest of atomic abundances in astrophysics plasmas, as well as the recent activities on cold plasmas, it is important to have accurate atomic data available in the literature for atoms in various plasma environments. In the Debye-Hückel model for plasmas, the interaction potential between two charge particles is represented by a Yukawa-type potential, $\phi(r_a, r_b) = Z_a Z_b \exp(-|r_a - r_b| / \lambda_D) / |\vec{r}_a - \vec{r}_b|$, where $\mathbf{r_a}$ and $\mathbf{r_b}$ represent respectively the spatial coordinates of particles A and B, and Z_a and Z_b denote their charges. The parameter λ_D, called the Debye screening length, is a function of temperature and number density of the charge particles in the plasma. The smaller values of λ_D are associated with stronger screening. Using the stabilization method, we have recently made a first investigation on the $2s^2\ ^1S^e$ autoionization resonance in Ps^- embedded in various model plasma environments [2]. Here, we employ an alternate approach, a complex-rotation method [3], to study higher-lying resonances in Ps^-. The non-relativistic Hamiltonian (in Rydbergs) describing the negative positronium ion in Debye plasmas is

$$H = -\frac{1}{2}\nabla_1^2 - \frac{1}{2}\nabla_2^2 - \frac{1}{2}\nabla_3^2 - \frac{\exp(-r_{13}/\lambda_D)}{r_{13}} - \frac{\exp(-r_{23}/\lambda_D)}{r_{23}} + \frac{\exp(-r_{12}/\lambda_D)}{r_{12}},$$

where 1, 2, and 3 denote the two electron 1, 2 and the positron respective and r_{ij} is the relative distance between the particle i and j. For S-states we use Hylleraas-type wave functions to describe the system,

$$\Psi_{kmn} = \sum_{kmn} C_{kmn} (\exp[-\alpha(r_{13} + r_{23})] r_{12}^k r_{13}^m r_{23}^n + (1 \leftrightarrow 2)) \ ,$$

with $k + m + n \le \omega$, and ω, l, m and n are positive integers or zero. In the present work, wave functions with up to ω=18 (N=715) are used. In the complex-rotation method, the radial coordinates are transformed by $r \to r\, e^{i\Theta}$, and the kinetic and potential parts of the Hamiltonian are transformed to the form of $-(1/2)\nabla^2 e^{-2i\Theta}$ and $-(1/r)$¢í^{i}Ð¢ñ$\Theta}$ $\exp(-re^{i\Theta}/\lambda_D)$, respectively. Fig.1 and Fig.2. show, respectively, the resonance energy and width for the $3s^2\ ^1S^e$ resonance state as a function of $1/\lambda_D$. More results will be reported at the meeting.

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