Metastable-bound $2pnf$ ($^1F^e$) states of helium like systems under Debye plasma

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Synopsis Precise energy eigenvalues of doubly excited bound $^1F^e$ states originating from $2pnf$ ($n = 4-10$) configuration of He like atoms under Debye plasma have been calculated by using Ritz variational method in Hylleraas coordinates.

In recent years, studies of atomic systems under external plasma environment have received considerable momentum because of their wide application in astrophysics, plasma physics, condensed matter physics, and many other areas. Such studies are of particular interest in the diagnostic determination of inertial confinement fusion (ICF) plasmas, in studying the X-ray opacity of matter in stellar interiors, atomic energy level population kinetics, radiation energy flow, and electron thermal conduction [1, 2]. Structral and spectroscopic properties of atomic systems placed under plasma confinements change appreciably compared with those of free atoms. Typical examples of weakly coupled plasma are the gaseous discharge plasma, plasma in controlled thermonuclear reaction, solar coronal plasma, tokamak plasma and so on. For the investigation of weakly coupled plasma the advantage of the Debye model [2] lies in the fact that the screening constant is a function of temperature and plasma density and a variety of plasma conditions can be obtained by changing the screening constant. Investigations on doubly excited states of helium-like atoms embedded in Debye plasma are very limited [3].

The energy eigenvalues of doubly excited $2pnf$ ($^1F^e$) bound states ($n = 4-10$) of a neutral helium atom and singly ionized lithium atom are estimated under weakly coupled plasma screening using an explicitly correlated multi-exponent Hylleraas-type basis in the framework of the Rayleigh-Ritz variational principle. The Debye screening model has been employed to include the effect of plasma background.

The non-relativistic Hamiltonian for a two electron atom under Debye plasma is expressed as [4]

$$H = -\frac{1}{2}\nabla_1^2 - \frac{1}{2}\nabla_1^2 - \frac{Z}{r_1}e^{-r_1/\lambda} - \frac{Z}{r_2}e^{-r_2/\lambda} + \frac{1}{r_{12}}e^{-r_{12}/\lambda}$$

where Z is the atomic number. The modified energy eigenvalues of metastable bound $2pnf$ ($^1F^e$) states ($n = 4-7$) for Li^+ are plotted as a function of the Debye screening length λ as shown in Figure 1. A decrease of the Debye screening length gradually destabilizes the two-electron atoms by pushing the energy levels towards zero and ultimately ionizing the two-electron atoms as is evident from the Figure.

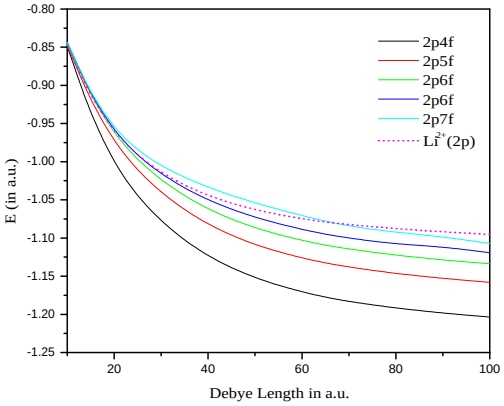

Figure 1. Plot of energy values of $2pnf$ $^1F^e$ states $n = 4-7$ of Li^+ against Debye length

References

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