Spectral properties of hydrogen-like ions in finite-temperature quantum plasmas

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Synopsis The oscillator strengths and radiative transition probabilities for the Lyman and Balmer series for transitions up to n=5 of a hydrogen-like ion embedded in a finite-temperature quantum plasma are calculated in a wide range of plasma densities and temperatures. The plasma screened Coulomb interaction includes the quantum electron degeneracy, exchange-correlation and finite-temperature gradient correction effects.

The screened Coulomb interaction between charged particles in various plasma environments leads to significant effects in structural and collision properties of atomic systems embedded in such plasmas. Previous investigations have used the Debye-Hückel potential to study the weakly coupled hot dilute systems [1] and the modified Debye-Hückel potential [2] to investigate the cold dense quantum plasmas.

The gradient corrections and quantum exchange correlation effects for the dense plasma are involved by the Lindhard linear response theory in the finite-temperature quantum plasma potential [3]

$$V(r) = -\frac{Z}{2r}[(1+\alpha)\mathrm{e}^{-r/\lambda_-} + (1-\alpha)\mathrm{e}^{-r/\lambda_+}], \qquad (1)$$

where λ_- acts as the modified screening length, and λ_+ arise from the first-order perturbation.

In this work, we study the spectral properties of a hydrogen-like ion in dense plasmas characterized by Eq. (1). The results for the oscillator strengths at temperatures 0.35eV and 3.5keV are compared with those for zero-temperature quantum plasmas and for Debye plasmas, respectively.

In Figure 1 we present the density dependence of oscillator strengths for the transitions of Lyman series, for plasma temperatures of 3.5eV, 35eV, 350eV and 3500eV. The oscillator strengths for all these temperatures first very slowly decrease with increasing the plasma density but the decrease becomes very sharp when approaching the density value corresponding to the critical screening length for the upper state. The oscillator strengths also rapidly decrease with increasing the principal quantum number of the upper state. It should also be noted that with increasing plasma temperature the values of the oscillator strength for a given transition extend to increasingly higher plasma densities.

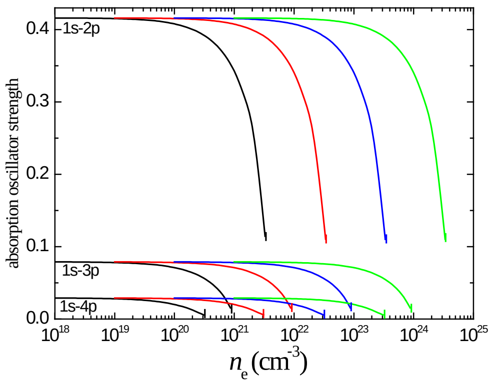

Figure 1. Oscillator strengths for the Lyman series transitions as function of the mean electron density n_e, for plasma temperatures T_e=3.5eV (black lines), T_e= 35eV (red lines), T_e= 350eV (blue lines) and T= 3500eV (green lines).

References

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