Magic wavelengths of Ca$^+$ ion for linearly and circularly polarized light

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Synopsis The dynamic dipole polarizabilities of the low-lying states of Ca$^+$ ion for linearly and circularly polarized light are calculated by using relativistic configuration interaction plus core polarization (RCICP) approach. Present magic wavelengths for linearly polarized light agree with the available results excellently. Additional magic wavelengths have been found for circularly polarized light, which is very useful for magnetic-sublevel selective trapping.

The magic wavelength, at which the two levels of transitions have same AC stark shifts, was introduced in Refs. [1, 2]. It has been of great interest in ultraprecise optical lattice clocks and the state-insensitive quantum engineering [3, 4]. For circularly polarized light, the dynamic polarizability has vector and tensor component. The dynamic polarizability is different for different magnetic sublevels of atomic states.

In this work, the dynamic dipole polarizabilities of the 4s, 4p_j and 3d_j states of Ca$^+$ ion for linearly and circularly polarized light are calculated by using relativistic configuration interaction plus core polarization (RCICP) approach. The basic strategy of the model is to partition the atom into valence and core electrons. The orbitals of the core are written as linear combinations of S-spinors which can be treated as relativistic generations of Slater-type orbitals. The orbitals of valence are written as linear combinations of L-spinors and S-spinors. L-spinors can be treated as relativistic generalizations of the Laguerre- type orbitals.

Fig.1 shows the dynamic polarizabilities of 4s and 4$p_{1/2}$ states for the linearly (A=0) and left handed (A=-1) polarized light. In Fig.1 (a), three magic wavelengths are found, which are in good agreement with available results [5, 6]. Fig.1 (b) gives the dynamic polarizabilities for A = -1 for 4$s_{m=-1/2}$ and 4$p_{1/2m=-1/2}$ states. There are only two magic wavelengths are found for 4s − 4$p_{1/2}$ transition. There is no magic wavelength between 4p$_{1/2}$ − 5s and 4p$_{1/2}$ − 4$d_{3/2}$ transition energy. The magic wavelength 395.5410 nm very close to the magic wavelength 395.1788 nm for 4s - 4$p_{1/2}$ transition for A=0. Another magic wavelength 778.3726 nm occurs between 4p$_{1/2}$ − 4s and 4p$_{1/2}$ − 3$d_{3/2}$ transition energy. It has 87 nm difference with the magic wavelength 691.2444 nm for linearly polarized light.
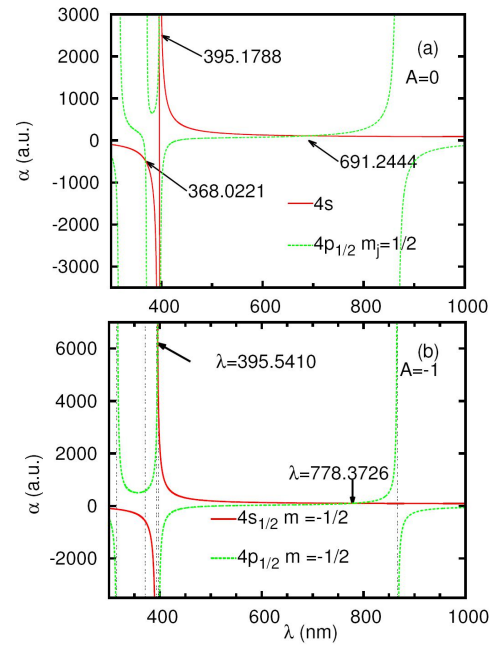

Fig. 1. Dynamic polarizabilities (in au) for the 4s - 4$p_{1/2}$ of Ca$^+$ for the linearly (A= 0) and left handed (A=-1) polarized light. Magic wavelengths are identified by arrows.

References

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