Magic wavelengths for the $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_1$ transition in ytterbium atom

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Synopsis The electric-dipole dynamic polarizabilities of the $6s^2\,{}^1S_0$ and $6s6p\,{}^3P_1$ states of Yb atom are calculated by using the CI+MBPT method. Magic wavelengths for the $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_1$ transition are identified.

The magic wavelengths for a transition are wavelengths of the laser field at which the ac Stark shift of the transition energy is zero so that the transition frequency is insensitive to the laser intensity [1]. Using the optical trap with a magic wavelength could permit coherent control of electronic transitions independent of the atomic center-of-mass motion. Up to now, the magic wavelengths for the clock transition $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_0$ in ytterbium have been well investigated [2]. However, no study on magic wavelengths for the $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_1$ transition in Yb is available. Indeed, the ${}^1S_0$ - ${}^3P_1$ transition in bivalence atom including Yb is also vital in many experiments involving laser cooling and trapping such as the measurement of the atomic electric dipole moment [3].

In this work, the electric-dipole dynamic polarizabilities of the $6s^2\,{}^1S_0$ and $6s6p\,{}^3P_1$ states of Yb atom are calculated by using the configuration interaction plus many-body perturbation theory (CI+MBPT) method [4] and the CI-MBPT program package [5]. The one-electron basis set for the calculation includes 1 - 23s, 2 - 22p, 3 - 22d, 4 - 20f, and 5 - 18g orbitals, where the core and 6 - 9s, 6 - 9p, 5 - 8d orbitals are Dirac-Hartree-Fock (DHF) ones constructed by solving the DHF equations in the V^N, V^{N-1}, V^{N-2} approximations step by step, while all the rest orbitals are virtual ones. The polarizabilities are determined by using the sum-over-states method employing the calculated reduced dipole matrix elements and the experimental transition energies.

The dynamic polarizabilities of $6s^2\,{}^1S_0$ and $6s6p\,{}^3P_1$ states at photon frequencies below 0.115 a.u. are shown in Fig. 1. 'Magic' conditions occur when the polarizabilities of the two states intersect off resonance marked by small circles with numbers on the plot. We predict thirty-six magic wavelengths as is shown in Table 1, while sixteen of them, from No. 7 to No. 22, are located in the visible region.

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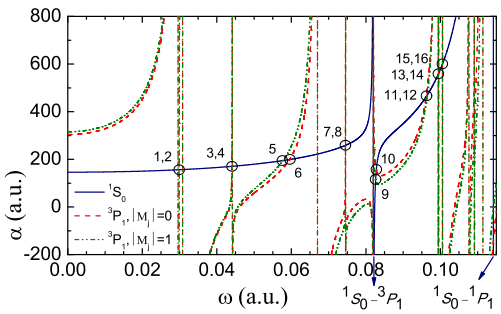

Figure 1. (color online) Dynamic polarizabilities of $6s^2\,{}^1S_0$ and $6s6p\,{}^3P_1$ states of Yb atom.

Table 1. Magic wavelengths for the $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_1$ transition in Yb atom.

No.	λ^*(nm)	No.	λ^*(nm)	No.	λ^*(nm)	No.	λ^*(nm)
1	1526.19	10	550.38	19	417.62	28	379.35
2	1522.80	11	473.76	20	417.60	29	378.06
3	1035.36	12	472.67	21	410.67	30	377.83
4	1035.24	13	458.23	22	410.02	31	369.33
5	789.64	14	458.19	23	387.38	32	369.19
6	766.13	15	453.21	24	387.38	33	364.27
7	611.45	16	453.21	25	379.93	34	364.07
8	611.35	17	423.78	26	379.93	35	335.05
9	551.59	18	423.71	27	379.36	36	334.75

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