Determination of dipole polarizabilities and magic wavelengths for Yb atom

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Synopsis The static and dynamic electric-dipole polarizabilities of the $6s^2\,{}^1S_0$, $6s6p\,{}^3P_0^o$ and $6s6p\,{}^3P_1^o$ states of Yb atom are calculated based on the CI+MBPT method. The magic wavelengths for the $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_0^o$ and $6s^2\,{}^1S_0$ - $6s6p\,{}^3P_1^o$ transitions are determined.

The optical trapped ytterbium (Yb) atoms provide a promising tool to study many fundamental problems in modern physics. But the optical trapping potentials must cause spatially inhomogeneous energy shifts of the atomic states so that can seriously affect the experimental results. Fortunately, a carefully designed optical trap with a magic wavelengths that shifts the energies of the selected states equally, as proposed by Katori *et al.* [1], provides a solution to this problem.

In this work, we employed a relativistic *ab initio* method based on a combination of configuration interaction (CI) method and many-body perturbation theory (MBPT) [2, 3, 4] to evaluate the energies and electric-dipole (E1) matrix elements of many low-lying excited states of the Yb atom. Then, the static (when laser frequency ω=0) and dynamic (when $\omega\neq0$) electric-dipole polarizabilities of the $6s^2\,{}^1S_0$, $6s6p\,{}^3P_0^o$, and $6s6p\,{}^3P_1^o$ states of the Yb atom are calculated [5]. At last, numerous magic wavelengths for the $6s^2\,{}^1S_0 - 6s6p\,{}^3P_0^o$ and $6s^2\,{}^1S_0 - 6s6p\,{}^3P_1^o$ transitions are determined [6], respectively. The magic wavelengths identified for the clock transition $6s^2\,{}^1S_0 - 6s6p\,{}^3P_0^o$ are in good agreement with the previous works, which have been demonstrated in the atomic Yb clock experiments [7]. For the $6s^2\,{}^1S_0 - 6s6p\,{}^3P_1^o$ transition, we find five magic wavelengthes located on the red detuning region, at 1035.730 nm, 612.951 nm, 1517.684 nm, 1036.054 nm, and 858.142 nm, as shown in Figure 1. Such magic wavelengths are of particular interest for attaining the state-insensitive cooling, trapping, and quantum manipulation of neutral Yb atom.

This work is supported by the National Natural Science Foundation of China (Grant Nos. 91536106 and U1332206), the Strategic Priority Research Program (Category B) of the Chinese Academy of Sciences (Grant No. 21030300), and the National Key Research and Development Program of China (Grant No. 2016YFA0302104).

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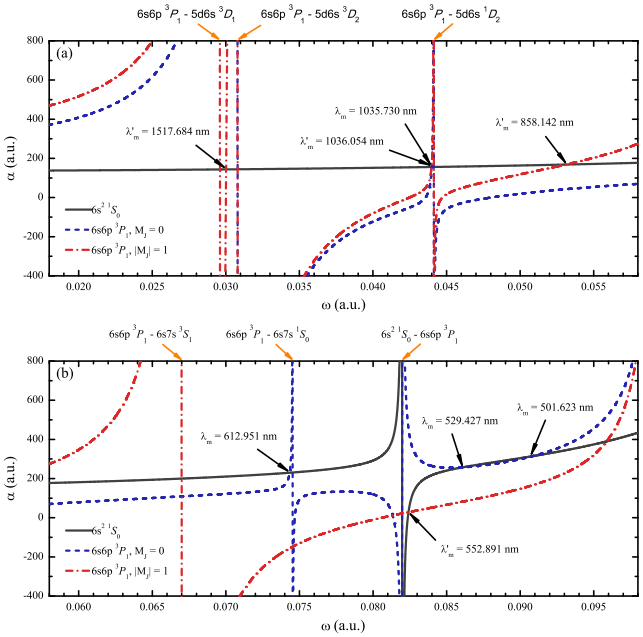

Figure 1. Dynamic dipole polarizabilities $\alpha(\omega)$ of $6s^2\,{}^1S_0$ and $6s6p\,{}^3P_1^o$ states and magic wavelengths for the $6s^2\,{}^1S_0 - 6s6p\,{}^3P_1^o$ transition of Yb atom.

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