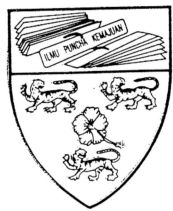
ANALYTICAL INVESTIGATION OF THE EFFECT OF DIPOLE-DIPOLE INTERACTION ON DISPERSION SPECTRUM



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ABSTRAK

Penyelidikan dilakukan keatas spektrum penyerapan-penyerakan bagi dua atom dua paras yang dipacu oleh suatu medan kuat yang koheren dan mengalami lembapan dalam vakum normal. Dua kes telah diuji: Dalam keadaan resonan bersama interaksi dwi-kutub dan keadaan bukan resonan tanpa interaksi dwi-kutub.

Di dalam keadaan resonan, kita telah meyelesaikan secara analitik persamaan master bagi operator ketumpatan atom terturun untuk model atom Dicke yang koheren yang berinteraksi dengan vakum normal dan menggunakan perisian manipulasi simbol bagi memperolehi spektrum penyerapan-penyerakan. Kita tunjukkan bagi frekuensi Rabi yang besar untuk medan koheren (iaitu apabila frekuensi laser ditala kepada frekuensi peralihan atom), indeks biasan boleh dibesarkan tanpa berlaku penyerapan. Walau bagaimanapun, bila frekuensi laser tersebut tidak ditala kepada frekuensi peralihan atom, tiada indeks biasan yang besar ditemui tanpa berlaku penyerapan. Kita juga mendapati kehadiran interaksi dwi-kutub adalah sangat perlu untuk jalur sisi Rabi terbelah menjadi doublet. Interaksi ini juga menyebabkan kewujudan jaluran sisi tambahan Rabi. Dengan ini mengesahkan keputusan yang telah diperolehi oleh Agarwal et al. (1981).

Dalam keadaan bukan resonan, teknik penghampiran sekular untuk sistem dua atom dua paras digunakan bagi mengira ungkapan analitik spektrum penyerapan-penyerakan. Kita tunjukkan bahawa pada kehadiran penalaan, tiada indeks biasan yang besar bersama penyerapan sifar ditemui dekat jaluran sisi Rabi. Walau bagaimanapun, pada frekuensi pusat spektrum kita dapati penyerakan adalah finit bila tiada penyerapan. Keputusan ini disahkan kemudian melalui analisis berangka.

ABSTRACT

A study is made of the absorption-dispersion spectra of two collective two-level atoms driven by a strong coherent field and damped by normal vacuum. Two cases are examined: on-resonance case with the inclusion of dipole-dipole interaction and off-resonance case without the inclusion of dipole-dipole interaction.

In the on-resonance case, we have solved analytically the master equation for the reduced atomic density operator for the coherently driven Dicke model interacting with a normal vacuum and used a symbolic manipulating software to obtain the absorption-dispersion spectra. We show that for large Rabi frequencies of the driving field (i.e. when the frequency of laser is tuned to the atomic transition frequency), the index of refraction can be enhanced at vanishing absorption. However, when the frequency of laser is not tuned to the atomic transition frequency, we do not find any large refractive index accompanied by vanishing absorption. We also find that the presence of the dipole-dipole interaction is essential for the Rabi side bands to split into doublets and also the existence for additional Rabi side bands. This confirms results obtained by Agarwal et al. (1981).

In the off-resonance case, the secular approximation technique for a system of two two-level atoms is used to calculate an analytical expression for the absorption-dispersion spectra. We show that, in the presence of detuning we do not find any large refractive index accompanied by vanishing absorption at the Rabi side bands. However, at the central frequency of the spectrum, we show that the dispersion is finite when absorption is zero. This is confirmed by numerical results.

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