Coherent Populations Trapping for Multilevel Systems in the External Magnetic Field

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We consider the influence of external magnetic field on the coherent population trapping effect for multilevel atomic systems. Our theory and method of calculation for interaction of multilevel atom with intense radiation field at the presence of external magnetic field have been applied for considering coherent population trapping (CPT) effect for different systems of atoms. The considered power densities may be up to gigawatt/cm^2 and magnetic field strength up to $10^5 Oe$. Hyperfine structure may be neglected for considered field strength. As considered effects can be obtained experimentally at low concentrations of vapours (10^{13}-10^{14} cm^{-3}) we may neglect the processes of collision relaxation. Hamiltonian of interaction consists of spin - orbit interaction, interaction with radiation fields (in dipole approximation) and with external magnetic field. For atoms with large fine structure interval compared to Rabi frequencies and splittings due to magnetic field, spin - orbit interaction must be included into unperturbed Hamiltonian. Such situation takes place for Tl atoms. The wave function is found as decomposition into the set on eigenfunctions of unperturbed Hamiltonian in LSJM - representation. Substituting it into Schrodinger equation, one obtains in resonant approximation the system of equations for coefficients of the set, the order of which depends on the number of sublevels, coupled by interaction with two radiation fields and by magnetic interaction. For example, for $3(4)S_{1/2}$-$3(4)P_{1/2(3/2)}$-$5(6)S_{1/2}$ transitions in alkaline atoms (Na, K) there is the system of ten equations which can be reduced to the two systems of five equations in the simplest case of two linear polarized laser beams traveling parallel to magnetic field. For considered levels of Tl ($6P_{1/2}$-$7S_{1/2}$-$6P_{3/2}$) we have the system of eight coupled sublevels. So we have to use the numerical methods for finding the eigenvalues (quasienergies) and eigenfunctions of the systems.The programmes for calculations are based on the method the essence of which is the sorting programme permitting to obtain the plots of quasi-energies depending on parameters. The most difficult problem is the interpretation of the curves at these plots.

For some sets of parameters for one of the systems of coupled magnetic sublevels coherent population trapping takes place and for another the population of intermediate level is extremely small, especially for the intense field of laser radiation. The results of computer simulations in Tl atoms show that it is possible to obtain narrow resonance in fluorescence, because the multilevel system has the behavior inherent to three-level system. Also it is possible to obtain population inversion between magnetic sublevels of excited state of an atom.