AD-A193 335 COOPERATIVE EFFECTS AND INTRINSIC OPTICAL BISTABILITY IN COLLECTIONS OF ATOMS(U) TECHNION RESEARCH AND DEVELOPMENT FOUNDATION LTD HAIFA (ISRAEL) Y BEN-ARYEH 1/1

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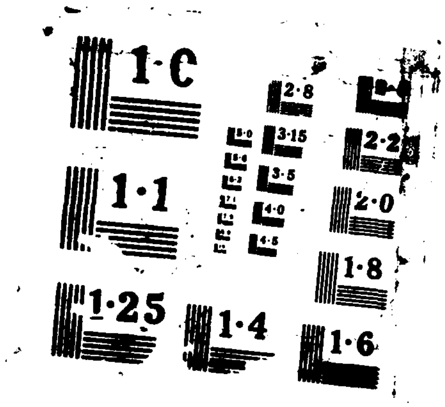
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First Interim Report to the US Army

1. Research Project: "Cooperative Effects and Intrinsic Optical Bistability in Collections of Atoms", R&D # 5859-PH-01
2. Principal Investigator: Prof. Y. Ben-Aryeh
3. Contractor: Technion Research & Foundation LTD.
4. Contract No: DAJA 45-87-C-0040
5. First Interim Periodic Report
6. Report Period: October 1st 1987 till November 30, 1987.
7. The Research reported in this document has been made possible through the support and sponsorship of the U.S. Government, through its European Research Office of the U.S. Army. This report is intended only for the internal management use of the Contractor and the U.S. Government.

1. Scientific Work Done During the Reporting Period

In order to understand the basic nature of cooperative effects between different atoms we have treated during this period the cooperative effects between two atoms interacting one with another via the vacuum field and under the influence of applied coherent electro-magnetic field. We have studied the problem of resonance fluorescence from two two-level atoms and have developed a new treatment to this problem by using the methods of Stenholm and Baklanov, which have been used previously only for one atom. We have given the full and maximally simplified equations so that anybody who is interested in the two atom resonance fluorescence spectra can calculate it by the use of a computer for any specific case. For the special case of two two-level atoms within a distance smaller than a wavelength and for a strong external field analytical results have been developed.

It has been predicted in previous works by other investigators that the spectrum of cooperative systems would consist not only of the usual peaks, but also of additional sidebands at the harmonics of the Rabi frequency. In the present study, we have found that although these additional sidebands exist in the spectra, they become extremely weak for strong external field. The equations developed by us enable one to calculate further the dependence of the resonance fluorescence spectra on the strength of the external field. The physical effects in cooperative resonance fluorescence are very similar to those of intrinsic bistability as both phenomena are related to coherent dipole-dipole interactions. In intrinsic bistability a first order phase transition between a cooperative and a non-cooperative behaviour appears as a function of the intensity of the external field. We intend to use our equations for studying analogous effects in the resonance fluorescence spectra.

The Langevin equations for intrinsic bistability, which had been derived in previous works, were based on complete factorization of the dipole operators. We have introduced a partial factorization, by which the expectation values are factorized only relatively to the atoms. The deviation from complete factorization is then due to the Langevin noise terms. We have started to study the effects of the noise terms on the phenomenon of intrinsic bistability. We have simplified the quantum statistical treatment of the intrinsic bistability for the case where the dephasing constant is much larger than the relaxation constant. For this case the expectation values for the complex dipole operators are adiabatically eliminated. We have obtained by this approximation a one-dimensional Ito differential equation for the inversion of population and we are now studying further the methods for solving this equation.

2. During the first year of the contract, we intend to develop and solve the equations for intrinsic bistability taking into account the effects of the Langevin noise terms.

We will continue also our study of the resonance fluorescence spectra of two two-level atoms.

In the second year, we will continue the study of quantum and classical fluctuations in intrinsic bistability by numerical simulations as described in the contract.

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