Atomic Ionization in Bright Non-Classical Light

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Nowadays different types of non-classical field states are generated and are available in experiment: Fock states, coherent states with small number of photons, photon pairs and bright squeezed vacuum states of light. Squeezed non-classical electromagnetic field states can be generated for example in the parametric down conversion process when the pump wave goes through the nonlinear crystal with $\chi^{(2)}$ nonlinearity and gives rise to creation of the signal and idler photons with strong correlation between them. If the pump intensity is high enough the resulting squeezed field state can contain huge number of photons up to 10^{13} per mode and can effectively interact with atomic and molecular systems. The interaction of such non-classical states with atoms remains still an open question and can lead to new important physical effects absent in the case of classical light. It should be noticed that strong coupling between an atom and quantum field can be also achieved even for not very high mean photon numbers if the atom is placed in a high-Q cavity or by strong focusing of the non-classical light.

In this work the interaction between an atom and non-classical light is considered in the strong-coupling regime and the atomic ionization is analyzed theoretically. In the case of classical field the Ionization of atoms was investigated by Keldysh [1], using the expansion over the known Volkov states characterizing the behavior of a free electron in a strong laser field. Similar approach is used in this work to describe atomic ionization induced by non-classical light. To do this we use the eigenfunctions known for a free electron in a quantized electromagnetic field found by Berson [2] and Bergou [3] in the relativistic and non-relativistic regimes correspondently.

Using the Keldysh-like approach the ionization rate of an atom is calculated for different types of the quantum field interacting with the atomic system: Fock states and their superpositions, coherent states and squeezed light states are used as the initial field condition. The analytical expressions for ionization rate in different multi-photon channels are found. The influence of the coherent superposition of different Fock states in the initial field state on the atomic ionization is analyzed. Specific features of the atomic dynamics in the non-classical squeezed light are established. The possible interference effects are discussed. The obtained results are compared with the case of classical field and Fock state in the limit of very high photon number.

References

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