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BOOK OF ABSTRACTS

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Manifestation of Multiple Dressed States in Hyperfine Levels of Na: the Death of Dark and some Bright Components in Autler-Townes Spectra

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We conducted theoretical studies of the formation of laser induced adiabatic states in a multilevel two-state quantum system with Hyper Fine (HF) splitting which is essential in observing laser-matter interaction phenomena under experimental conditions. Our numerical data for a typical optical Autler-Townes (AT) [1] experiment in a three-level ladder scheme (a weak probe field in the first excitation step and a strong coupling field in the second step) shows essential diminishing of AT spectra components due to newly created dark states in the system. For a specific excitation ladder scheme $3S_{1/2}(F'' = 2, 1) \rightarrow 3P_{3/2} \rightarrow 4D_{5/2}$ in sodium we also demonstrate the death of some bright AT which was a novel unexpected result. Our theoretical treat revealed a number of nontrivial moments in the manifestation of HF adiabatic states depending on the coupling laser intensity:

(i) At intermediate coupling field Rabi frequencies the HF operator is comparable to the coupling one, which results in noticeable mixing between different orthogonal adiabatic wave functions, in particular, between individual sets of bright and dark states. The mixing populates dressed states which are decoupled from the excitation scheme, e.g. "gray" states, and gives rise to a number of extra AT multiplets.

(ii) At large coupling field strengths, the HF atomic operator is treated perturbatively; the number of bright and dark states and their explicit representations is found from the classical Morris-Shore transformation [2]. Multiple dark states are created from the "grey" ones, while some "bright" AT components gradually die with the increase of coupling laser power.

From a practical point of view our most important finding consists in that probing from the ground state HF sublevel F''=2 or F''=1 results in the appearance of quite different AT components. The multiplets originating from the different ground state sublevels are complementary to each other, i.e. at high coupling field powers the probe laser populates different orthogonal configurations of adiabatic states depending on the HF-channel (F''=2 or =1). In terms of applications this opens, for instance, nontrivial perspectives to form a two-component bichromatic polariton: a single strong control laser can drive the independent propagation of two uncoupled quantum probe fields.

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References

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