Light scattering by a dense, microscopic cloud of cold atom two level atoms

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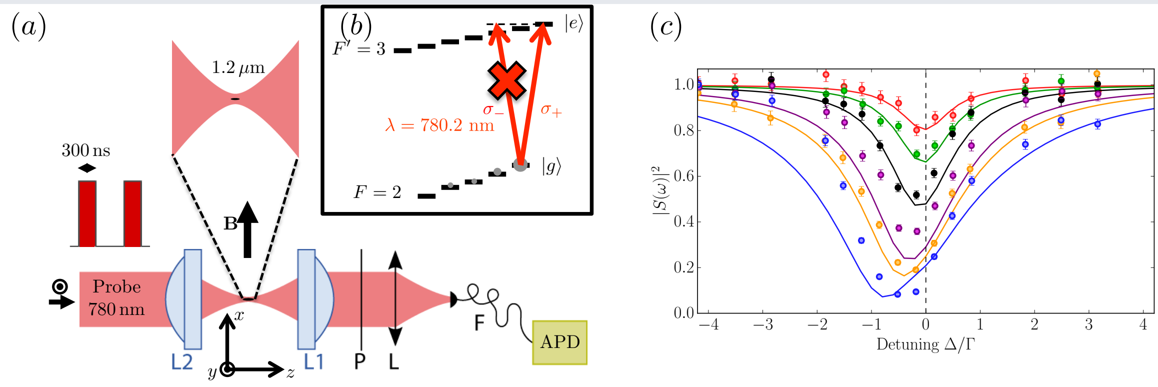
The study of the coherent scattering of light in a dense medium has regained a new interest in the few last years, owing to its important implications for applications to atomic sensors, atomic clocks, nano-optics and the study of ultra-cold atomic gases. When the medium is dense and the frequency of the light is tuned near an atomic resonance, the light induced dipoles are large and interact via the dipole-dipole interactions, which in turn modify the scattering. This effect may ultimately affect the accuracy of atom-based sensors such as atomic clock.



Many experimental works have been devoted to the study of scattering by dilute cold laser-cooled atomic samples. However the case of high density has been much less explored. In the first experiment in this regime, performed in 2014 at the Institut d' Optique using a dense, microscopic cloud of cold rubidium atoms, the state-of-the art theoretical model failed to reproduce the data, most likely due to the complicated internal structure of the atoms. In the framework of the PhD thesis of Stephan Jennewein (project ECONOMIQUE, collaboration between LCF and LAC), we have measured the coherent response of the cloud (see figure a), but this time applying a strong magnetic field (300 G) to isolate a two-level structure in rubidium (figure b). We measured the trasnmission of a probe propagating through the cloud for different atom numbers (from 5 to 100, figure c). Moreover we developed a new model based on the generalization of the Bloch-Maxwell formalism, which bears the potential to explore the high intensity regime in the future. The results are in much better agreement wit the data than any previous studies: this is the first time a theory is able to fit experimental results in this high-density regime. This opens new perspectives to realize recent proposals, such as a mirror consisting of a plane of atoms structured in an array, or non-linearities induced by the interactions that could provide new ways to generate non-classical states of light.

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