Faraday filtering in atomic vapours: from Hamiltonian to application

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The interaction between atoms and light is of essential importance in many areas of physics, and a quantitative understanding of this interaction is therefore beneficial for a variety of reasons, both from the point of view of fundamental physics and for designing applications. We have developed a detailed numerical model [1] of the electric susceptibility (*ElecSus*) for alkali-metal vapours that calculates transition strengths and frequencies, and accounts for applied magnetic field, Doppler broadening and several other experimental effects.

ElecSus can be used as a tool to fit experimental data [2] or predict novel effects, and has already found use in designing an atomic optical isolator [3]. Here we explore one particular application of *ElecSus*; Faraday filtering (often called FADOF filters). A Faraday filter is a high-contrast, ultra-narrow bandpass filter that utilises the birefringent and dichroic properties of atomic media in an applied magnetic field. The filter's transmission profile is strongly dependent on the magnetic field strength and the atomic number density. ElecSus has been used to optimise the performance of such filters, and we see excellent agreement between the theoretical prediction and experimental data [4].

Finally, we explore a further application of Faraday filtering in the context of laser design. Frequency selection is achieved by placing an atomic Faraday filter inside the external cavity of a diode laser system. By carefully engineering the optimal conditions for Faraday filter performance, it is possible to realise a single-mode, single-frequency laser which operates only at the cooling/repump transition frequencies. We envisage that such a system can become a turn-key, maintenance-free laser system for laser cooling experiments.

References

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