6.4 Optically Enhanced Magnetic Resonance of Atom-Surface Interactions

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Optical spectroscopy can be applied to atoms in the proximity of a solid surface by reflecting a laser beam at the surface while taking advantage of the fact that the reflectivity is resonantly modified by the atomic transitions. Spectroscopic data like the shifts of resonance frequencies or modifications of the shape, width, and strength of the resonance lines provide information about the interaction between the atoms under investigation and the surface.

We have applied this technique to the interface between glass and spin polarized sodium vapor in a buffer gas, aiming at the investigation of spin relaxation due to wall collisions. A laser beam, which is resonant with the Na atoms, is reflected at the interface at an angle close to the critical angle for total internal reflection, thereby probing a thin vapor layer above the glass surface. The spin polarization is created by optical pumping with a second laser beam and makes the vapor optically anisotropic. This results in a change of the polarization of the reflected probe beam, which is measured and provides the information about the ground state orientation of the atoms. An optically enhanced magnetic resonance is realized by inducing a spin precession in a transverse magnetic field via polarization modulation of the pump beam. This modulates the optical anisotropy of the atomic vapor and allows the signal to be extracted by means of a Lock-in amplifier. Thus, we achieve the high sensitivity required to detect the weak signal, which stems from a layer containing only ~10^5 atoms.

In a first step, the experimental results concerning line shapes and angular dependence of the signal were compared with a theory, where the atomic vapor is treated as a homogeneous anisotropic medium. The main features are described in a qualitatively correct manner by the theory but a number of deviations exist, which can be interpreted as due to spin relaxation at the wall making the medium spatially inhomogeneous. Diffusion of polarized atoms through the buffer gas to the wall, relaxation at the wall, and the restoration of the polarization of atoms leaving the wall lead to a gradient of the magnetization close to the wall. For a proper description of this situation, the theory was extended to one-dimensionally inhomogeneous, anisotropic media by calculating the reflection properties in a perturbation-theoretical approach. On the basis of these results, the modification of the optical line shape and signal strength by disorienting wall collisions can now be described theoretically in a quanitative manner in fair agreement with the experiment.