

Evanescent Wave Spectroscopy of Atomic Sublevel Coherences

Tilo Blasberg, Dieter Suter,

*Institute of Quantum Electronics,
Swiss Federal Institute of Technology (ETH) Zürich,
CH-8093 Zürich, Switzerland*

and

Jürgen Mlynek

*Department of Physics, Universität Konstanz,
D-7750 Konstanz, Germany*

Spatially selective spectroscopic information from atoms near an interface can be obtained from the modification of the reflectivity of the interface¹. The high sensitivity and spatial selectivity of these optical methods makes them also an attractive tool for the measurement of other atomic quantities, e.g. order within the sublevels of the atomic ground state. In this contribution we show for the first time that it is possible to obtain spectroscopic information on the Zeeman transitions of atoms located near a glass-gas interface. The method uses an optical pump field to excite the atomic resonances and a second optical field as a probe. We show that the major signal features can be calculated from a relatively simple theory by taking into account the modifications of the complex index of refraction of the atomic medium by the magnetization present in the system.

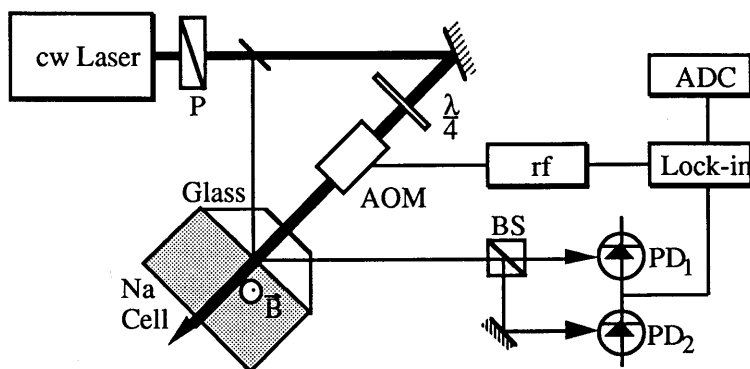


Figure 1: Schematic representation of the experimental setup used for evanescent wave spectroscopy of atomic sublevel coherences.

The basic experimental setup is shown in figure 1²: the Na gas used as the atomic medium is contained in a glass cell and optically pumped with a circularly polarized laser beam whose intensity is modulated with a rf frequency near the Larmor frequency. The linearly polarized probe beam is incident on the interface at an angle near the critical angle for total internal reflection. The reflected beam is monitored by a polarization-selective detector, yielding a signal that is proportional to the magnetization in the atomic gas. This signal depends on the frequency at which the intensity of the pump laser beam is modulated and reaches a maximum if the modulation frequency becomes equal to the Larmor frequency.

In order to calculate the expected signal, we approximate the Na level system as a homogeneously broadened $J=1/2 \leftrightarrow J'=1/2$ system. Under our experimental conditions, the signal is determined only by the ground state orientation. In the linear regime, the signal can be calculated from the complex index of refraction of the atomic medium which differs for the two different states of circularly polarized light. In the region of total internal reflection, the signal is determined by the difference of absorption between the two circular polarization components, while it is due to the different dispersion in the region of partial reflection. The theoretical and experimental lineshapes are compared in figure 3 for the two regions. Experiments like the one described here might be useful for the study of absorption / desorption processes on the surface of solid materials.

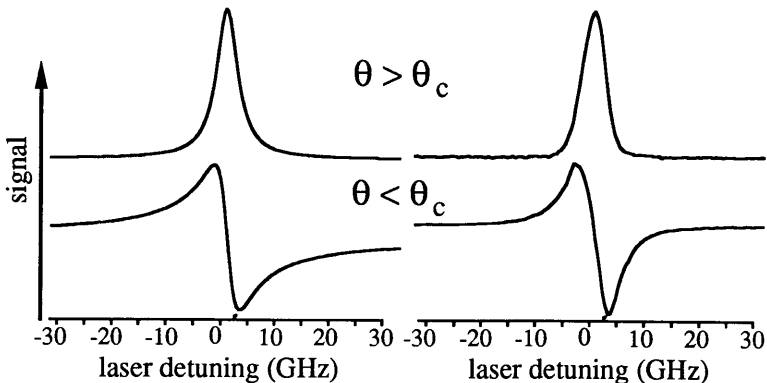


Figure 2: comparison of calculated (left) vs. experimental (right) signal as a function of laser detuning in the totally reflective (top) and partially transmitting regime (bottom). θ_c denotes the critical angle.

1. See e.g. P. Simoneau, S. LeBoiteaux, C.B. DeAraujo, D. Bloch, J.R. R.Leite, M. Ducloy, *Optics Comm* **59**, 103 (1986); A.M. Akul'shin, V.L. Velichanskiĭ, A.I. Zherdev, A.S. Zibrov, V.I. Malakhova, V.V. Nikitin, V.A. Sautenkov, and G.G. Kharisov, *Sov. J. Quantum Electron.* **19**, 416 (1989), and references therein.

2. D. Suter, J. Äbersold and J. Mlynek, *Optics Commun*, in print (1991).