SELECTIVE REFLECTION SPECTROSCOPY WITH A HIGHLY PARALLEL WINDOW: PHASE-TUNABLE HOMODYNE DETECTION OF THE RADIATED ATOMIC FIELD

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Selective reflection (SR) of light from a cesium vapor-sapphire interface, close to the D_2 resonance line, has been studied by use of a sapphire window with highly parallel surfaces. Temperature-tuning of the Fabry-Perot behaviour of the window, resulting in a change of 0.5 to 26 % of the window reflection coefficient, dramatically affects both the magnitude and lineshape of the SR resonant atomic signal. For nearly zero window reflection, the case of particular interest, the absorptive properties of the atomic medium govern the signal shape, as opposed to the dispersive ones in the "ordinary" SR. This manifests phase tunability of homodyne detection of the radiated atomic field. The numerical simulation based on a model, which accounts for all the processes involved, shows a good agreement with the experimental spectra. Possible application for laser and atomic spectroscopy, in particular tunable locking of laser frequency, is discussed.

Selective reflection (SR) spectroscopy is usually performed in vapour cells with a wedged window. This prevents contributions to the SR signal due to interference with the beam reflected from the outer side of the window. We report, for the first time to our knowledge, SR spectroscopy measurements made with a cell having highly parallel windows. The recorded spectra are dramatically affected by the interference in the window[1]. When the two reflected beams interfere constructively (reflection maximum), the spectra display sub-Doppler features associated with the real part of the atomic response, as is usual in SR spectroscopy. By contrast, when the reflected beams interfere nearly destructively, the spectra are characterised

by absorptive lineshapes, indicating that the imaginary part of the atomic response is dominant. Indeed, the use of a parallel window allows homodyne detection of the radiated atomic field. Phase tuning is achieved by choosing the order of the interference, here using temperature control of the window[2] (Figure 1).
The spectra are presented together with a qualitative explanation of this behaviour. Then we present a calculation of the reflected intensity, which takes into account, to all orders, the interference in the window. The model, with no adjustable parameter except the exact window thickness, shows excellent agreement with the spectra recorded on the caesium D2 line[1].

The interest of this experimental technique is that one can switch from one regime to the other very easily by changing the window temperature by a few degree Celsius (about 17°C in the case of our 0.5mm thickness sapphire window). It also allows tunable laser frequency locking with a slope of about 2MHz/°C in our case.

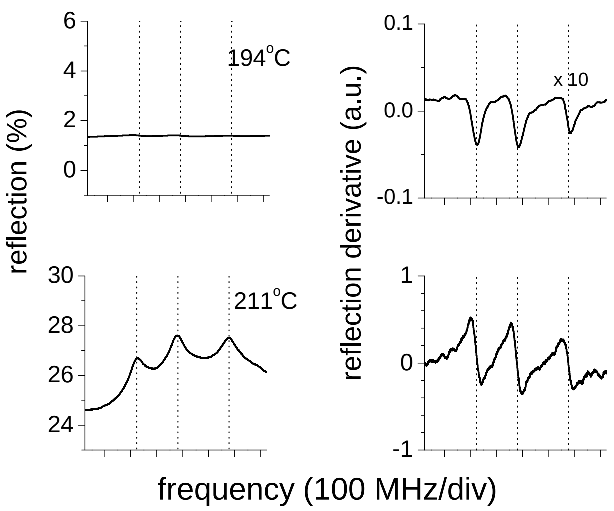

Figure 1. Measured SR spectra and their frequency derivatives for window temperature tuned to minimum (upper row) and maximum (lower row) reflection.

References

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