



HAL
open science

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

Aram V. Papoyan, G. G. Grigoryan, S. V. Shmavonyan, David Sarkisyan,
Jocelyne Guéna, Michel Lintz, Marie-Anne Bouchiat

► **To cite this version:**

Aram V. Papoyan, G. G. Grigoryan, S. V. Shmavonyan, David Sarkisyan, Jocelyne Guéna, et al..
SELECTIVE REFLECTION SPECTROSCOPY WITH A HIGHLY PARALLEL WINDOW: PHASE
TUNABLE HOMODYNE DETECTION OF THE RADIATED ATOMIC FIELD. 8th EPS conference
on atomic and molecular physics, 2004, Rennes, France. pp.4-84. hal-00002633v2

HAL Id: hal-00002633

<https://hal.science/hal-00002633v2>

Submitted on 27 Aug 2004

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

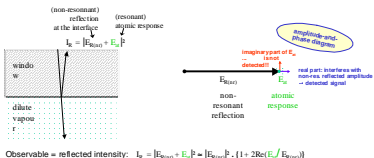
SELECTIVE REFLECTION SPECTROSCOPY WITH A HIGHLY PARALLEL WINDOW: PHASE TUNABLE HOMODYNE DETECTION OF THE RADIATED ATOMIC FIELD

A. V. Papoyan, G. G. Grigoryan, S. V. Shmavonyan, D. Sarkisyan,
Institute for Physical research, NAS of Armenia, Ashtarak-2, 378410, ARMENIA

J. Guéna, M. Lintz, M.-A. Bouchiat,
LKB, Département de Physique de l'ENS 24 rue Lhomond, 75 231 Paris cedex 05, FRANCE
(to be published in *Eur. Phys. J. D*)

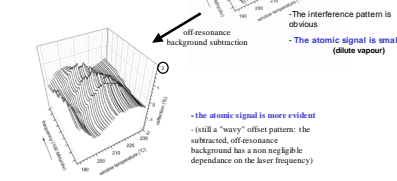
the hidden side of the
selective reflection signal

"ordinary" selective reflection



- How to detect the imaginary part?? Some proposals have been made:
- Brewster incidence ($E_{\text{refl}} \perp \vec{k}$) (Mandel et al. Soviet J. Opt. Technol. 41(6), 416)
 - multi-layer coating (these work by interference and Fresnel (see Comptes Rendus 315))
 - metallic coating (these work by interference and Fresnel (see Comptes Rendus 315))
 - considerable attenuation of the atomic signal, due to the required metal thickness

The raw signal on the Cs D1 line



The model

Continuity equations at the two boundaries between the three media:

- air, $n_1=1$
- (sapphire) window, $n_2=1.76$
- vapour, $n_3=1$

Maxwell equations for the propagation of the backward atomic field in the vapour (without using the slowly varying envelope approximation)

assuming cell length \gg absorption length (no backward beam coming from $z=0$)

then $E_{\text{refl}} = \left[\frac{n_2^2 - n_1^2}{n_2^2 + n_1^2} \exp(i\phi) \right] E_0 + \frac{n_2^2 - n_1^2}{n_2^2 + n_1^2} \exp(i\phi) E_{\text{at}}$

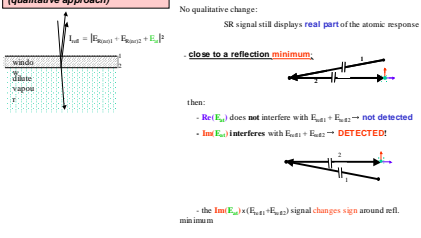
(where the n_2 and n_3 are the amplitude transmission and reflection coefficients) and the backward atomic field is generated by the vapour atomic polarisation:

$$E_{\text{at}} = 2ik \int_0^L P(z) \exp(2ikz) dz$$

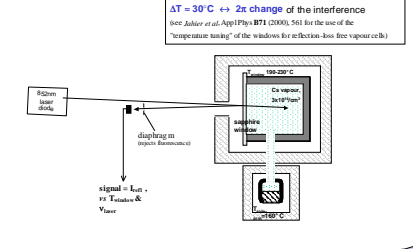
Defining the atomic response, by $\frac{P(z) \exp(2ikz)}{E_{\text{refl}}}$ and assuming the absence of saturation and non-linearity, we get (F, Γ, ν_0 homogeneous and Doppler widths):

$$\chi^* = \frac{N \mu^2}{h} \frac{1}{\nu - \nu_0 + i\Gamma} \frac{1}{1 - \frac{F^2}{4(\nu - \nu_0 + i\Gamma)^2}}$$

selective reflection with a parallel window



The experiment



Conclusion

The model and experiment agree very well (no fitted parameters) on the size and the temperature dependence of the spectra.

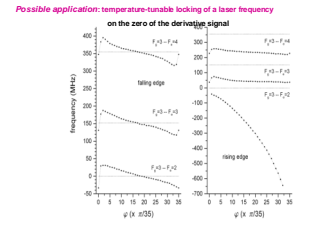
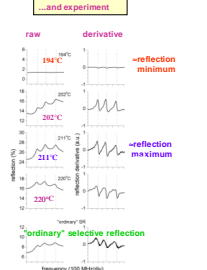
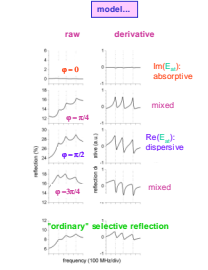
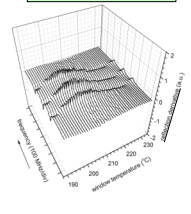
By using a "temperature tunable" window, one can detect at will

- the real (dispersive) part
- or the imaginary (absorptive) part of the atomic response.

SR is better near the reflection minimum.

Changing from one regime to the other is obtained very easily, just by changing the window temperature by a few degrees C.

The raw and derivative signals



zoom at...

The minimum reflection regime

