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► To cite this version:

Jocelyne Guéna, Michel Lintz, Marie-Anne Bouchiat. symmetry discrimination and measurements of parity violating and magnetoelectric dichroisms in a Cs vapor. 8th EPS conference on atomic and molecular physics, 2004, Rennes, France. pp.1-3. hal-00002628

HAL Id: hal-00002628

<https://hal.science/hal-00002628v1>

Submitted on 20 Aug 2004

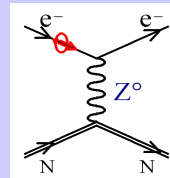
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SYMMETRY DISCRIMINATION AND MEASUREMENTS OF PARITY VIOLATING AND MAGNETOELECTRIC DICHROISMS IN A Cs VAPOUR

J. Guéna, M. Lintz and M.-A. Bouchiat,

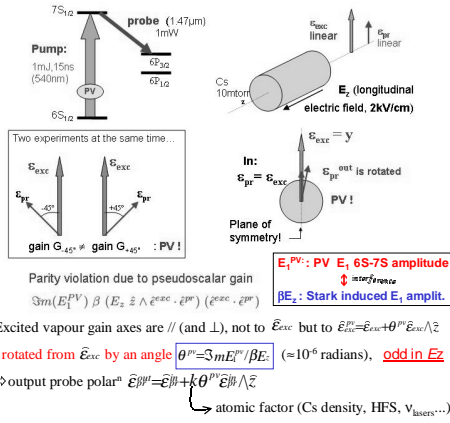
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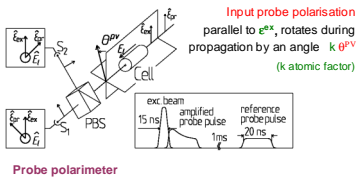
Particle physics...
...at low energies!

PRINCIPLE OF THE EXPERIMENT

EXCITATION AND DETECTION



POLARIMETRIC METHOD OF MEASUREMENT ...and CALIBRATION

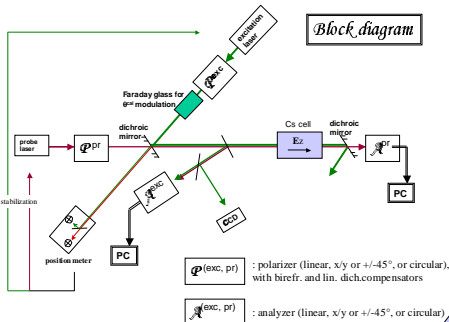


Selection criteria of the PV rotational invariant

Criteria	Selection of	against	Period
$D = \frac{S_x - S_y}{S_x + S_y}$	Imbalance between R-L configurations	intensity, population	each pulse
$\Delta D = D^{amp} - D^{ref}$	Atomic imbalance	non atomic	1 ms
$\pm \theta^{cal}$	imbalance D^{cal}	CALIBRATION	0.4s
E_z -odd	PV effect (main signature)	most PC E_z effects (Stark-Stark)	0.8s
Tilt (θ^{out} -odd)	True polarization effect	instrumental defects (EMI, geometrical)	6s
θ^{PV} [$\begin{matrix} \parallel E^{exc} \\ \perp E^{exc} \end{matrix} $ -even]	Linear dichroism (Atomic alignment)	optical rotation (e.g. Faraday)	12s
θ^{exc} -isotropic	Rotational invariant (cf "cylindrical symmetry")	stray transverse B_z, E_z field effects	2 mn

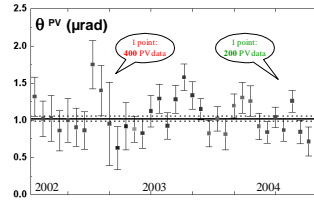
1 PV data

IMPLEMENTATION of the EXPERIMENT



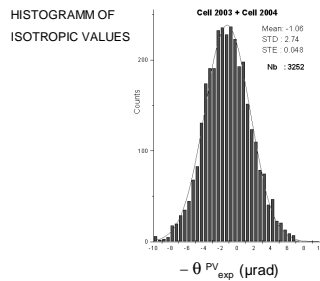
PRESENT RESULTS

EVOLUTION OF THE RESULTS (6 different cells)



Since first results (PRL, 2003), S/N improved by 3.3
=> acquisition time for S/N=1 reduced by 10

Current average result (at 1.74kV/cm): $\theta^{PV} = 1.019 \pm 0.034$ (μrad)
agrees with Boulder's more precise result



CYLINDRICAL SYMMETRY DISCRIMINATION AND THE MAGNETO-ELECTRIC EFFECTS

The experiment is invariant under rotations of ($\hat{E}_{exc}, \hat{E}_{pr}$) around $\hat{k} // \hat{E}$

4 Polarization config^{ns}: 0°, 45°, 90°, 135°



But is the isotropic part free from systematics arising from E_z , B_z fields or misalignments?

The case of transverse E and B fields:

Ideal situation: pure longitudinal E field (and probe polarization $\hat{E}_{pr} // \hat{E}_{exc}$)
-> (Stark) Parity-conserving alignment with axes \hat{E}_{exc} and $\hat{E}_{exc} // \hat{E}_{exc}$

-> no imbalance in output probe polarimeter

+ transverse E field

- > adds new Stark alignment, with revolution symmetry around \hat{z}
- > yet, no imbalance

+ transverse B field

- > Larmor precession of the E_z -induced alignment
- > this new rotated alignment is detectable by the probe
- > non-zero polarimeter imbalance:

θ^{PV} measured and reduced in dedicated sequences -> $\theta_{sys} \leq \theta^{PV} / 10$, corrected

This is a P-conserving "Jones Dichroism" (i.e. with axes at 45° from \hat{z}) due to the transverse E_z and B_z fields

Magneto-electric optical effects have also been observed in liquids, yet with a $B_z = 15T$ and $E_z = 1.7kV/cm$

Here it is easily observed with $B_z = 1G$, $E_z = 10V/cm$ in a dilute vapor, and fully understood

The case of a transverse E field and a pump-probe misalignment

a probe misalignment α is equivalent to a rotation of angle/direction of the probe with respect to the exc beam
-> is given by the above formula except for the replacement

$$E_z \rightarrow E_z \cos \alpha$$

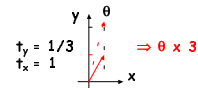
HOW TO AMPLIFY THE PV EFFECTS?

PASSIVE AMPLIFICATION

Polarization Magnifier at cell output :

Passive Amplification of the Polarization Tilt

dichroic component with axes x (transmission = 1) and y (transmission $T_y < 1$)



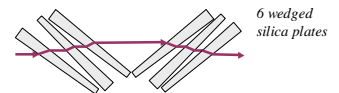
But... 9 x less photons detected :

photon shot noise also increased X 3 !

To gain in S/N we increase the probe intensity

How to make a polarisation magnifier ?

6 brewster plates... with no two surfaces parallel ! (interference + linear birefringence -> birefringence)



ACTIVE AMPLIFICATION

...by the atomic medium itself!

Excited vapour = anisotropic amplifier (η : gain anisotropy)

-> exponential growth of both

probe intensity and left-right asymmetry vs. optical density

$$A_{LR} \equiv 2 \theta^{PV} x [\exp(\eta A) - 1]$$

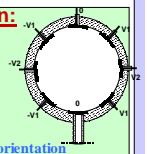
$$= 2 (E_z^{PV} / \beta E_z) x [\exp(\eta A) - 1]$$

where $A = \ln(I^{out} / I^{in})$: optical density, $\propto E_z^2$

-> Increase E_z at will? ...But cell is long (8cm)

-> high endcap potentials -> discharges at $E_z > 1.8kV/cm$

Exploiting further A_{LR} amplification: a new PV proposal in transverse E field



-> observable = PV excited-state orientation

The PV orientation is transverse

- > apply transverse B field -> longitudinal PV orientation
- > probe circ. dichroism, detected using circular analyser

Advantages of the transverse field configuration:

- Larger excitation rate (involves scalar polarisability $\alpha \approx 10\beta$),
- Longer interaction length is possible without discharges.

Cylindrical symmetry restored by rotating E and B fields by 45° steps
-> predicted quantum-noise limit improves by a factor 10, or even more in the triggered superradiant regime!

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