



## **symmetry discrimination and measurements of parity violating and magnetoelectric dichroisms in a Cs vapor**

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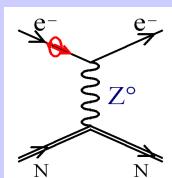
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# SYMMETRY DISCRIMINATION AND MEASUREMENTS OF PARITY VIOLATING AND MAGNETOELECTRIC DICHROISMS IN A Cs VAPOUR

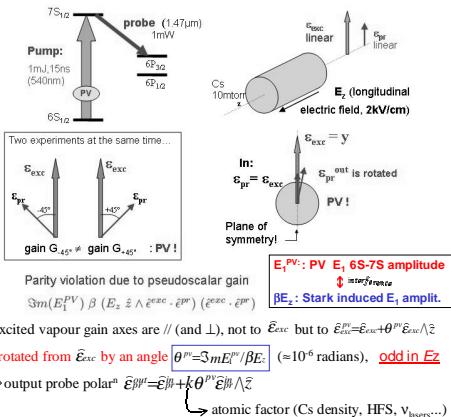
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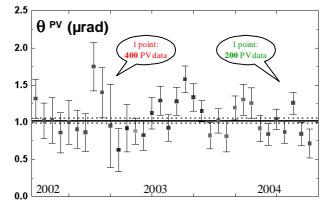
## PRINCIPLE OF THE EXPERIMENT

### EXCITATION AND DETECTION

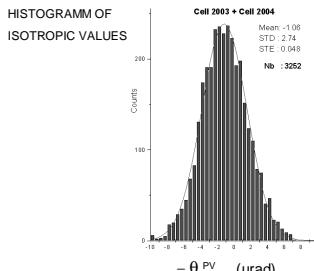


## PRESENT RESULTS

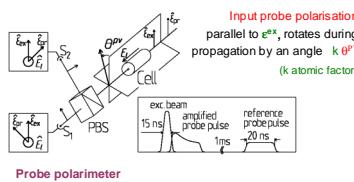
### EVOLUTION OF THE RESULTS (6 different cells)



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



## POLARIMETRIC METHOD OF MEASUREMENT ...and CALIBRATION



Probe polarimeter

Polarimeter imbalance ⇔ left-right asymmetry

$$A_{LR}(\theta^{PV}) \equiv (S_x - S_y)/(S_x + S_y) = 2 k \theta^{PV}$$

Calibration: rotating  $\hat{e}^{exc}$  by  $\theta^{cal}$  ⇒ probe rotation  $k \theta^{cal}$   
 $A_{LR}(\theta^{cal}) = 2 k \theta^{cal}$

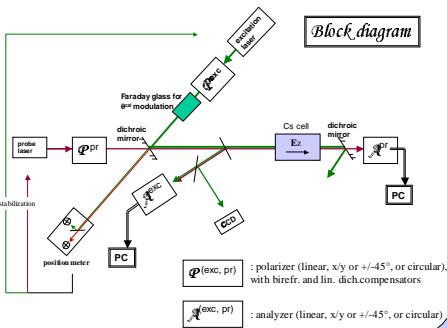
$$\theta^{PV} = [A_{LR}(\theta^{PV}) / A_{LR}(\theta^{cal})] \cdot \theta^{cal}$$

## 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
$\Delta D = D_{\text{amp}} - D_{\text{ref}}$	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
$\text{Tilt}(\hat{e}_{out}^{PV})$ -odd	True polarization effect	instrumental defects (EMI, geometrical)	6s
$\hat{e}_{in}^{PV} \{ \begin{array}{l} \parallel \hat{e}^{exc} \\ \perp \hat{e}^{exc} \end{array} \}$ -even	Linear dichroism (Atomic alignment)	optical rotation (e.g. Faraday)	12s
$\hat{e}^{exc}$ -isotropic	Rotational invariant (cf "cylindrical symmetry")	stray transverse $B_z, E_z$ field effects	2 mn

1 PV data

## IMPLEMENTATION of the EXPERIMENT



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

a probe misalignment  $\hat{e}^{PV} \rightarrow \hat{e}^{PV}$  is equivalent to a rotation of angle/direction  $\hat{e}^{PV} \rightarrow \hat{e}^{PV}$  is given by the above formula except for the replacement

## 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  $T_y \ll 1$ )

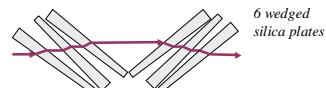
$$t_y = 1/3 \quad t_x = 1 \Rightarrow \theta \times 3$$

But... 9x 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

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

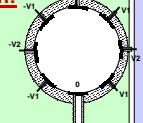
$$= 2 (E_1^{PV} / \beta E_z) \times [\exp(\eta A) - 1]$$

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  $\alpha = 10\beta$ ).

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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