

**THE CS PARITY VIOLATION EXPERIMENT IN PARIS:  
 $E_1^{PV}$  DETERMINATION WITHIN  $2 \times 10^{-13}$  ATOMIC UNITS**

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A precise atomic Parity Violation (APV) experiment provides an original test of the electron-nuclear weak interaction mediated by the neutral vector boson  $Z_0$ , a test complementary to high energy experiments. It consists in measuring a left-right asymmetry of  $\simeq 10^{-6}$  in the light-atom interaction, associated with a transition dipole  $E_1^{pv}$  of only  $10^{-11} ea_0$  in the highly forbidden 6S-7S transition of atomic cesium. Our pulsed pump-probe experiment, carried out in a vapor cell submitted to a longitudinal  $\vec{E}$ -field, provides a novel method of APV measurement by exploiting the amplification of the asymmetry by stimulated emission. Since the first demonstration in 2002, decisive improvements have been implemented and the latest runs performed in 2004 yield a 2.6% accurate determination of  $E_1^{pv}$ .

### 1. The present experiment: Principles and Results

We excite a cesium vapor on the 6S - 7S forbidden transition with a pulsed laser beam in presence of a parallel electric field  $\vec{E}$ . This creates a *transient* optical gain by stimulated emission on the 7S - 6P<sub>3/2</sub> transition probed with a resonant laser beam. Polarization analysis of the probe beam allows us to detect selectively a *chiral* contribution arising from the parity violating 6S - 7S transition amplitude  $E_1^{pv}$ . The plane defined by the excitation laser polarization and  $\vec{E}$  is a plane of symmetry of the experiment. If the probe linear polarization is at the input of the vapor inside the plane of symmetry, at the output *it deviates from this plane* by a small angle  $\theta^{pv}$  which changes sign when the direction of  $\vec{E}$  is reversed. This is a manifestation of the PV linear dichroism, whose eigenaxes are offset by 45° from the symmetry axes.

Rotational symmetry around the common pump-probe propagation axis is used to reduce systematic effects<sup>1</sup>. We have increased by a factor of 3.5 both the sensitivity and the accuracy of our initial 9% result<sup>2</sup>, thanks essentially to a polarization-tilt magnifier<sup>3</sup> as well as upgraded cesium cells with non-reflective windows metal-coated at the periphery for efficient application of the electric field<sup>4</sup>. Latest results<sup>5</sup> will be presented (Fig.1).

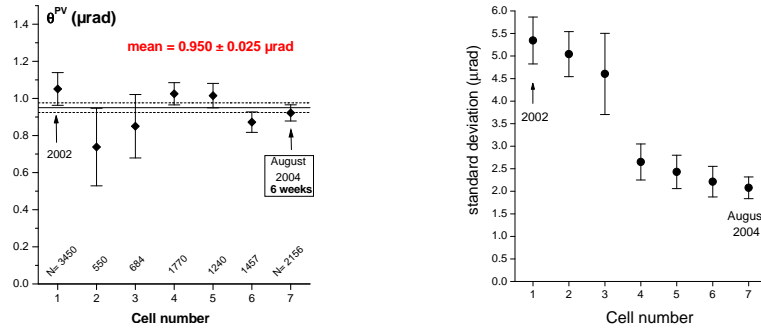


Figure 1. Left: Values of  $\theta^{pv} = -ImE_1^{pv}/\beta E$  ( $\beta$ : 6S - 7S transition polarizability,  $E=1.62\text{kV/cm}$ ) from data samples obtained in seven different Cs cells: mean (diamond) and statistical error. Right: Standard deviation of the PV data distribution showing improvements in signal-to-noise. Excited hyperfine component: 6S,  $F=3$  - 7S,  $F=4$ .

## 2. Project

We propose a novel kind of magneto-optical effect manifesting parity violation, as a possible observable for APV measurements to the 0.1% precision level on the 6S-7S Cs transition: a PV *circular dichroism* in *transverse* electric and magnetic fields, detectable on the collinear probe beam<sup>6</sup>. The advantage, as compared to the longitudinal  $\vec{E}$  field configuration, is that the interaction length can be made much longer without increasing the applied potentials. Thanks to the much larger optical density of the excited vapor, stimulated emission gives rise to considerable amplification of the polarimetric signal during propagation of the probe beam. Moderate transverse electric fields (a few hundreds V/cm) would allow one to reach the triggered superradiance regime, for further enhancing the PV asymmetry. We suggest a means of rotating the transverse direction of the fields so as to restore the cylindrical symmetry and suppress systematic effects.

## References

1. M.A. Bouchiat, J. Guéna and M. Lintz, *Eur. Phys. J.* **D28**, 331 (2004).
2. J. Guéna *et al.*, *Phys. Rev. Lett.* **90**, 143001 (2003).
3. M. Lintz *et al.*, *Rev. Sci. Instr.* **76**, 4, 043102 (2005), arXiv:physics/0410044.
4. D. Sarkisyan *et al.*, arXiv:physics/0504020, to appear in *Rev. Sci. Instr.*
5. J. Guéna *et al.*, arXiv:physics/0412017, to appear in *Phys. Rev.* **A** (2005).
6. J. Guéna, M. Lintz and M.A. Bouchiat, *J. Opt. Soc. Am.* **B22**, 21 (2005).