OVAL experiment:
Search for Vacuum Magnetic Birefringence with pulsed magnet and high finesse Fabry-Pérot cavity

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Introduction

QED prediction: an interaction of light and magnetic field in vacuum

- As a result, a refractive index becomes anisotropic (VMB)
  \[ \Delta n = k_{cm} \times B^2 \quad (k_{cm} = 4.0 \times 10^{-24} [T^{-2}]) \]
- Axion-like particles and MCP also induce VMB. → One of the best probe for ALPs as a terrestrial experiment.

- How to detect?
  \[ \Delta n \text{ changes the polarization} \] → Polarimetry with 2 polarizers

\[ \text{Sensitivity} \propto B^2 \times T_{DAQ}^{1/2} \]

Polarization change \[ \propto B^2 \times L \]
Noise contribution \[ \propto T_{DAQ}^{1/2} \]
Interaction length Enhancement \[ \propto F \] (F: cavity finesse)

OVAL (Observe VACuum with Laser) experiment is searching for VMB with pulsed magnet and Fabry-Pérot Cavity since 2016

VMB has not been observed yet...

Pulsed magnet

- Racetrack shaped coil with 1mm × 3mm Cu wire
  - 10kA @9T
  - Electromagnetic stress 40MPa

- Reinforcement with SUS

\[ \Delta n \text{ of the best contribution from ALPs is observed yet...} \]

Fabry-Pérot Cavity

- Composed with 2 very high reflective mirrors (R > 99.9999%)
- Cavity length 1.4m

\[ \text{Photon lifetime} \tau = F \text{cavity fineess}/4C \]

→ Measured finesse = 350,000
→ Effective pass length = 300km!!

Stable operation together

Test run & future prospect

- Test run of OVAL experiment is performed Dec 2017
- Total 6000 pulse was applied during 1 day
- Measured polarization change is fitted by magnetic field

No signal is observed

\[ k_{cm} < 6.5 \times 10^{-20} [T^{-2}] \] (95% C.L.)

Setup of test run

- Improvement of the cavity and the magnet is ongoing
  - Fabry-Pérot Cavity
    - Intensity fluctuation is limiting the sensitivity.
    - Intensity stabilization system is developed and now introducing to main optical system.
  - Pulsed magnet
    - New Ag-Cu wire is now planned. → Up to 16 T

- QED predicted VMB will be observed in 200 days