Precise alignment monitor by using optical frequency comb
for the muon g-2/EDM experiment at J-PARC

Tatsuya KUME¹, Tsutomu MIBE², Shoichiro NISHIMURA³, Mikio SAKURA⁴, Yutaro SATOH⁵, Wiroj SUDATHAM⁶,
Kiyoshi TAKAMASU⁷, Hiromasa YASUDA⁸, and J-PARC muon g-2/EDM collaboration
1: Mechanical Engineering Center, High Energy Accelerator Research Organization (KEK),
2: Institute of Particle and Nuclear Studies, High Energy Accelerator Research Organization (KEK),
3: Department of Physics, The University of Tokyo,
4: Department of Precision Engineering, The University of Tokyo

Background: The muon g-2/EDM experiment at J-PARC and the positron tracking detector

The muon g-2/EDM experiment at J-PARC aims to measure muon's anomalous magnetic moment, g-2 with an precision of 0.1 ppm; and to search for electric dipole moment, EDM with a sensitivity of $10^{-21}$ e·cm.

In the experiment, tracks of decay positrons in a storage ring with a 3 T of uniform magnetic field are to be measured by a positron tracking detector. It consists of 48 rectangular platy parts called a vane. They are aligned radially in the storage ring and form a cylindrical array.

Purpose & Concept: To ensure the alignment accuracy by using a length measurement grid

In order to measure the positron track enough accurately, alignment accuracy for each vane was estimated to be better than 10 μrad for the skew and 200 μrad for the tilt. We consider adopting an alignment monitor for ensuring the alignment accuracy during the operation.

Technical features: Absolute distance interferometer by using an optical frequency comb and ball lenses

An optical frequency comb is an optical short pulse train with an extremely accurate and stable interval. The distance, $l_1 - l_2$, can be derived absolutely by using a relation

$$l_2 - l_1 = 2R \cdot f_{rep} + \Delta l,$$

where $c$: light speed in vacuum, $n$: refractive index of the air, $f_{rep}$: repetition frequency of the comb, $a$: an integer ($a = 0, 1, 2, ...$), and $\Delta l$: optical path difference within the pulse interval. $\Delta l$ is derived by monitoring position of the scanning mirror.

Current status: Preliminary confirmations for the idea
1. Derivation for the distance, $l_1 - l_2$ from the two fringe peaks

Two peaks of the interference fringes for each light from the fixed mirror and the moving mirror can be observed. The distance between the two fringe peaks changes with the position of the moving mirror. It follows that the distance between the two mirrors can be derived from the distance between the two fringe peaks.

Outlook: We are going to realize multiple length measurement paths for constructing preliminary 3D-length measurement grid, and demonstrate deriving 3D-coordinate of each node for the grid.

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