Contribution ID: **257** Type: **Poster**

The detection of spin- and velocity-dependent exotic interaction at the micrometer range

Wednesday, 10 July 2024 17:10 (20 minutes)

Theories beyond the Standard Model usually predict the existence of new particles and interactions. Assuming that there are new bosons with spin of 0 or spin of 1, the exchange of these bosons can give rise to sixteen types of interactions. Here we present the experimental progress in the detection of one of them, the spin- and velocity-dependent interaction, at the micrometer range using a cantilever. A home-built scanning probe microscope is used to detect the interaction between polarized electrons in a periodic FeCo film structure (spin-modulated structure) and unpolarized nucleons in a gold sphere glued on the cantilever. During data acquisition, the spin-modulated structure is driven to vibrate in a sinusoidal form. If the exotic interaction exists, the gold sphere will sense a periodically time-varying force produced by the spin-modulated structure. The displacement of the cantilever is measured in real-time using a fiber interferometer. The exotic interaction is modulated to the 10th harmonics of the driving frequency, which helps to separate the spurious signals from the signal of interest in the frequency domain. Since the new interaction is proportional to the relative velocity between the two objects, the driving frequency is optimized to 18.85 Hz to increase the effect of the new interaction and minimize the vibration disturbance. The noise floor of the sensor is about ~20 fN/√Hz at 188.5Hz. It is expected that the limit on the spin- and velocity-dependent interaction will be improved by one order of magnitude compared to the previous constraint.

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Session Classification: Poster session

Track Classification: Parallel session: Axion/Sterile