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Slotted Rotatable Target Assembly and Systematic Error Analysis for a Search for Long Range Spin Dependent Interactions From Exotic Vector Boson Exchange Using Neutron Spin Rotation

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Abstract

We discuss the design and construction of a novel target array of nonmagnetic test masses used in a neutron polarimetry measurement made in search for new possible exotic spin dependent neutron-atom interactions of Nature at sub-mm length scales. This target was designed to accept and efficiently transmit a transversely polarized slow neutron beam through a series of long open parallel slots bounded by flat rectangular plates. These openings possessed equal atom density gradients normal to the slots from the flat test masses with dimensions optimized to achieve maximum sensitivity to an exotic spin-dependent interaction from vector boson exchanges with ranges in the mm - μm regime. The parallel slots were oriented differently in four quadrants that can be rotated about the neutron beam axis in discrete 90° increments using a Geneva drive. The spin rotation signals from the 4 quadrants were measured using a segmented neutron ion chamber to suppress possible systematic errors from stray magnetic fields in the target region. We discuss the per-neutron sensitivity of the target to the exotic interaction, the design constraints, the potential sources of systematic errors which could be present in this design, and our estimate of the achievable sensitivity using this method.

Over the last decade a growing number of experiments have sought new interactions of Nature with weak couplings and force ranges at the mm - μm scale. Such exotic interactions might arise from string theory, from pseudo-Goldstone bosons generated by spontaneous symmetry breaking at high energy scales, from the as-yet-unknown physics behind dark energy, etc. A detailed review on the state of this developing subfield can be found in [1, 2].

¹This is the author's personal address.

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