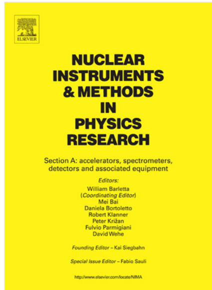
Accepted Manuscript



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PII: S0168-9002(18)30519-9
DOI: https://doi.org/10.1016/j.nima.2018.04.025
Reference: NIMA 60745

To appear in: *Nuclear Inst. and Methods in Physics Research, A*

Received date : 10 November 2017
Revised date : 10 April 2018
Accepted date : 15 April 2018

Demonstration of sensitivity increase in mercury free-spin-precession magnetometers due to laser-based readout for neutron electric dipole moment searches

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Abstract

We report on a laser based ^{199}Hg co-magnetometer deployed in an experiment searching for a permanent electric dipole moment of the neutron. We demonstrate a more than five times increased signal to-noise-ratio in a direct comparison measurement with its ^{204}Hg discharge bulb-based predecessor. An improved data model for the extraction of important system parameters such as the degrees of absorption and polarization is derived. Laser- and lamp-based data-sets can be consistently described by the improved model which permits to compare measurements using the two different light sources and to explain the increase in magnetometer performance. The laser-based magnetometer satisfies the magnetic field sensitivity requirements for the next generation nEDM experiments.

Keywords: Zeeman effect, atomic spectroscopy, mercury, electric dipole moment, neutron

1. Introduction

The search for a permanent electric dipole moment of the neutron (nEDM, d_{n}) is considered one of the most important experiments in low-energy particle physics [1]. Any permanent electric dipole moment (EDM) violates parity P and time-reversal symmetry T. Invoking the CPT theorem (C charge conjugation symmetry), an EDM also violates CP symmetry, an ingredient needed to explain the observed matter-antimatter asymmetry of the Universe [2]. This motivates EDM searches in molecular or atomic systems, nucleons, and bare leptons. A detailed review of the sensitivity provided by the different systems to the underlying physics can be found in [3]. The neutron as bare nucleon offers direct access to its EDM without being embedded in a more complex electronic or nuclear structure.

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