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A deep ultra-violet frequency-quadrupled diode laser system for the mercury co-magnetometer in the nEDM experiment

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e present a frequency lock for a DUV frequency-quadrupled diode laser system based on the sub-Doppler DAVLL (dichroic atomic vapor laser lock) technique applied to the \SI{253.7}{\nano\meter} transition in mercury. The laser system is part of a free induction decay magnetometer based on the optical detection of nuclear magnetic resonance (ODMR) in a spin polarized ensemble of ^{199}Hg atoms. The magnetometer is employed in the neutron electric dipole moment (nEDM) experiment at the Paul Scherrer Institute, Switzerland (PSI). The Standard Model (SM) of Particle Physics predicts a nEDM, breaking time reversal (T) and parity (P) symmetry, several orders of magnitude below the current best experimental limit $d_\mathrm{n} <$ \SI{2.9E-26}{\ecm} (\SI{90}{\percent} CL, [1]). However many theories beyond the SM predict values for a nEDM on the level of the current experimental sensitivities. Thus, neglecting the QCD θ-term, the search for a nEDM probes the parameter space of the SM extensions free from SM background. The experiment at the new UCN source at PSI aims at a factor five improved sensitivity and will place a limit of $d_\mathrm{n} <$ \SI{5E-27}{\ecm} at \SI{95}{\percent} CL [2] in case no nEDM is found. In the next step the sensitivity will be improved by another order of magnitude, $d_\mathrm{n} <$ \SI{5E-28}{\ecm} at \SI{95}{\percent} CL in case no nEDM is found.\newline
The nEDM experiment uses Ramsey's method of separated oscillatory fields to detect a shift of the Larmor frequency of stored ultra-cold neutrons (UCN) in a parallel and an anti-parallel configuration of magnetic and electric fields. To extract and survey the time stability ($\approx$
$numE - 8$ over \SI{100}{\second}) of the magnetic field ($\approx$
$SI1microtesla$) a spin polarized ensemble of ^{199}Hg atoms is added to the UCN storage chamber and acts as a co-magnetometer. The free spin precession of the ^{199}Hg atoms after a $\pi/2$ flip is detected as amplitude modulation of a circularly polarized DUV light beam traversing the UCN/Hg storage volume in the spin precession plane. With the new laser system we have achieved a six fold increase of the modulation signal compared to the light from a ^{204}Hg discharge lamp used so far. Furthermore we have an improved control of vector light shift effects that could induce systematic frequency shifts on the level of the nEDM sensitivity correlated to necessary polarity reversals of the magnetic/electric fields. This project is supported by the Swiss National Science Foundation under contract number 200021_126562.

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