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Current developments of polarized sources and polarimeter at FZ Jülich and further applications

A better theoretical understanding of the quantum mechanical processes in spin filter for the separation of metastable hydrogen atoms in individual hyperfine substates enables a number of new applications. For example, it is now possible to build a new generation of Lamb-shift polarimeter that can separate not only α but also the β states with $m_J = -1/2$. This opens up completely new possibilities for the search of hydrogen atoms in forbidden substates after the bound beta decay of the neutron. At the same time, corresponding simulations also provide the parameters for designing a Lamb-shift polarimeter for $^3He^+$ ions. Furthermore, it has recently been shown that classical Lamb-shift polarimeter can determine the polarization, in addition to protons/deuterons and H/D atoms, of H_2/D_2 molecules as well as all possible ion beam species, i.e. $H_2^+/D_2^+/HD^+, H^-/D^-$ or even H_3^+.

In parallel, this knowledge might help to create a new type of optically pumped polarized source by transferring a laser-induced polarization of the rotational magnetic moment to the nucleons in H_2/D_2 and HD molecules. These techniques might also be used for the production and detection of polarized fuel for the enhancement of the energy output of nuclear fusion reactors or the production of hyperpolarized probes in medicine.

A recent application was a proof-of-principle measurement of the polarization conservation in H_2 molecules after recombination of polarized atoms in a carbon-coated storage cell, similar to the cell that is foreseen for a planned polarized target at the LHCb experiment. In addition, in some more exotic experiments the components of a Lamb-shift polarimeter can be used to detect axions or "dark hydrogen" .

Primary author: Dr ENGELS, Ralf (Forschungszentrum Jülich)

Co-authors: Dr KANNIS, Chrysovalantis (Heinrich-Heine-Universität Düsseldorf); Mr SALMANN, Jonas (GSI Helmholtzzentrum für Schwerionenforschung); FAATZ, Nicolas (GSI Helmholtzzentrum für Schwerionenforschung); PÜTZ, Simon Jakob (University of Cologne/ GSI Darmstadt); EL-KORDY, Tarek (FH Aachen-University of Applied Sciences and Forschungszentrum Jülich); Mr VERHOEVEN, Vincent (Ruhr-Universität-Bochum)

Presenter: Dr ENGELS, Ralf (Forschungszentrum Jülich)

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