The Ultra Cold Neutron Laboratory at the FRMII ◇

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Within the next years a laboratory for experiments with ultra cold neutrons (UCN) at the FRMII will be built. This laboratory is divided in several parts:

- The source for ultra cold neutrons, located close ($\sim$ 60 cm) to the reactor core of the FRMII inside the throughgoing beam port SR6.
- An experimental site for measuring the lifetime of the free neutron (PENeLOPE), located in the experiment hall of the FRMII, about 10 m away from the SR6 beam port exit.
- An experimental site to determine a possible electric dipole moment of the neutron (nEDM), located in the hall east of the FRMII.
- An experimental site for various short term experiments with UCN, located in the experiment hall of the FRMII next to the SR6 beam port exit.
- Several utility and supply setups.

Within the last year progress has been achived in constructing all the parts mentioned above.

Concerning the UCN source the evaluation of a prototype setup has been finished. These results show, that UCN production with a solid deuterium converter based on the superthermal principle [1,2] is a proper mechanism, that can be realized at a high neutron flux reactor like the FRMII. This UCN source will be installed in the throughgoing beam tube SR6, with its converter at a distance of $\sim$ 60 cm from the reactor core. Experimental results gathered with the prototype show, that at the SR6 beam port exit UCN densities of up to $10^4\,\mathrm{cm}^{-3}$ can be expected.

Within the last year important design parameters of the UCN converter and of the built-in components of the source have been fixed. Several supply parts for the source have already been ordered or are currently under construction. The approval procedure with the safety authorities is ongoing.

The neutron lifetime experiment PENeLOPE has already finished several preparatory steps towards its buildup. The design parameters have been fixed and several pre-experiments have been finished or are ongoing. Further informations on the detailed status of this experiment can be found in another article in this annual report.

The transport of UCN from their source to the experimental sites is a major issue for precision experiments, like the nEDM experiment, which has been investigated within the last year. The nEDM will be located in the hall east of the FRMII, which means that the UCN have to be transported $\sim$ 40 m from the source to the experiment. A new type of UCN guides based on the replica technique may transport the UCN several tens of meters with acceptable losses. The transport is accompanied by many wall reflections and the losses in transmission must be considered [3,4]. For instance, for a transmission of 50% for 40 m guide length a transmission of 98.3% per meter is required.

In order to qualify these guides the UCN transmission has to be determined with high precision. For this purpose we have developed a novel method [5]. The UCN were absorbed at the end of the guide in a vanadium disc producing the β-active ^{52}V (half life 3.74 min). The intensity of the 1434 keV γ-ray following the β-decay was measured. For comparatively small test pieces of UCN guides of the replica type (66 mm diameter) and of different length the transmission per meter was determined with $\pm 0.5\%$ precision, resulting in values in the range 95.6% to 95.9%. By an absolute calibration of the γ-ray detection system we deduced also the absolute value of the UCN current absorbed in the vanadium plate.

These experimental results show, that for a guide of a diameter as planned ($120 - 150$ mm) for the UCN line to the nEDM experiment located in the hall east, a transmission of better than 50% may be achieved, if UCN leakages from gaps at the guide-intersections are avoided.

The installation of such a large laboratory with many different parts in the vincinity of the FRMII is a challenging task, that can only be accomplished with support from many sides. We therefore greatfully acknowledge the financial support by the Deutsche Forschungsgemeinschaft (DFG), the Cluster of excellence 153 "Origin and structure of the universe" and the Forschungsneutronenquelle Heinz Maier-Leibnitz (FRMII), as well as the man-power and infrastructure support by the Maier-Leibnitz-Laboratorium (MLL).

References

[1] U. Trinks, F.J. Hartmann, S. Paul, W. Schott, Nucl. Instr. Meth. Phys. Res. **A440** (2000) 666

[2] A. Frei *et al.*, Eur. Phys. J. **A34** (2007) 119

[3] C. Plonka, P. Geltenbort, T. Soldner, H. Häse, Nucl. Instr. Meth. Phys.Res. **A578** (2007) 450

[4] V.V. Nesvizhevsky *et al.*, Nucl. Instr. Meth. Phys.Res. **A578** (2007) 435

[5] A. Frei, K. Schreckenbach, B. Franke, F.J. Hartmann, T. Huber, R. Picker, S. Paul, P. Geltenbort, *Transmission measurements of UCN guides by UCN capture activation analysis of vanadium*, handed in for publication to Nucl. Instrum. and Meth. in Phys. Res. A 2009.

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