First production of spin polarized neutrons at the UCN source at channel C of the reactor TRIGA Mainz

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Introduction: Ultra cold neutrons (UCN) with velocities < 7 m/s are a unique tool to address many questions of modern particle physics like e.g. the matter- antimatter asymmetry in our Universe or the understanding of the primordial baryogenesis directly after the Big Bang. Experiments with UCN, in this frame work, search for a non-zero electric dipole moment of the neutron or the precise determination of the neutron lifetime.

Our group in Mainz participates in such experiments, where the polarization of UCN and the analyzation of the spin orientation after certain storage time play an essential role. A brief summary of our work with polarized UCN is presented here:

Experiment at the new UCN source in Mainz: For the first time polarized ultra cold neutrons where produced. For that purpose a magnetized iron foil was placed in the UCN beam. This foil consists of a 500 nm Fe layer on 25 µm Al. The effective Fermi potential of the magnetic saturated iron depends on the orientation of the neutron spin relative to this magnetisation, thus working as a spin filter. UCN with velocities less than 4 m/s are being reflected. Between 4 m/s and 8 m/s, only UCN with an anti-parallel alignment of spin and magnetic field are transmitted. Neutrons with velocities greater than 8 m/s are transmitted regardless of their spin orientation. The detection of the spin orientation is achieved in the same way.

An essential tool for the work with polarized neutrons is a spin-flipper. The working principle of a broadband adiabatic spin-flipper can be found e.g. in [1]. It consists of a magnetic gradient field perpendicular to the direction of flight and an induced radiofrequency parallel to the direction of flight.

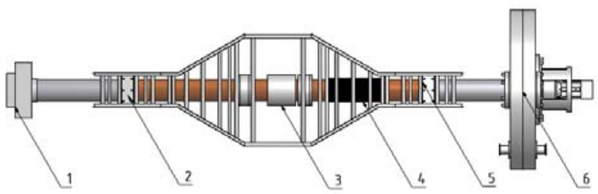

Figure 1. Setup for a polarization measurement.
(1) UCN detector, (2) analyzer foil, (3) grounded Al shielding to prevent RF in the second gradient, (4) RF coil, (5) polarizing foil, (6) Chopper. UCN come from the right side.

The polarization and the spin-flipp probability are velocity dependend. Therefore a chopper divides the continuous UCN beam into bunches and simultaneously starts a trigger signal on each bunch. The velocity is derived by measuring the UCN time of flight together with the length of the flight path.

Figure 1 shows a schematic draft of the experiment, as it was performed in January 2008 at the TRIGA Mainz.

Results: As shown in fig. 2, the measured polarisation depends on the velocity. It is zero for velocities greater than 8 m/s and comes close to 1 (i.e. 100%) for UCN slower than 6.8 m/s.

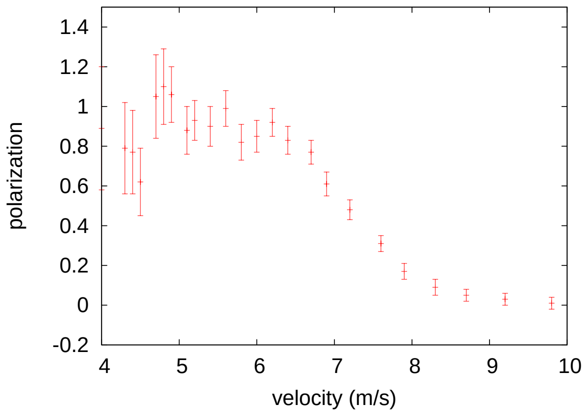

Figure 2. Measured polarization. For velocities less than 6.8 m/s the efficiency of the setup is close to 100 %.

The efficiency of the whole setup is given by the product of the efficiencies of the single components: Polarizer, spin-flipper and analyzer. Since the average value for UCN between 4.9 m/s and 6.9 m/s is 95 (± 3) %, one can assume that the efficiency of the single components (i.e. the polarization) is even higher.

References

[1] Grigoriev S.V., et. al. Peculiarities of the construction and application of a broadband adiabatic spin-flipper of cold neutrons. Nuclear Instruments and Methods in Physics Research, 1997; 451-456