

Production of Ultracold Neutrons (UCN) at the TRIGA Mainz

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During the last year a basic experiment with solid deuterium (sD_2) as converter material for production of UCN has been performed at the TRIGA Mainz. The goal of this experiment was to study the main important parameters for a optimized strong sD_2 source for UCN at the FRMII [1]. These parameters are: The way of freezing out the sD_2 , the optimal temperature of the sD_2 , the lifetime of UCN within the sD_2 , the dependance of the UCN production on the cold neutron temperature and the comparison of measured and calculated UCN production rates.

A schematic sketch of the test facility for investigating the UCN production at the TRIGA reactor Mainz is shown in Figure 1. So far, all test measurements were performed at the tangential beam tube C, where the thermal heat-load is considerably less. The very end of the in-pile part with the helium cooled converter head is positioned just in front of the graphite reflector. During the reactor pulse the thermal neutron flux amounts to $10^{15}n/(cm^2 \cdot s)$. The UCNs produced in the solid D_2 converter are guided outside the biological shield and finally are detected. This setup is composed of two main sections, the liquid He cooling system and the gas handling system. Auxiliary parts are the para-to-ortho deuterium converter and the remote control system. At this setup it's possible to freeze out $200\text{ cm}^3 sD_2$.

In Figure 2 the measured UCN count rates with the TRIGA experiment are shown for two different experimental setups. In one setup the sD_2 was exposed directly to the thermal neutron flux pulse of the TRIGA reactor. In the second setup the sD_2 was surrounded by the frozen premoderator Mesithylene (Trimethylbenzene). This premoderator was kept frozen at a temperature of 21K. Mesithylene down scatters the thermal neutrons to the cold neutron regime. The production of UCN in sD_2 is most efficient for incoming cold neutrons with an equivalent temperature of 30K [2]. In both setups the amount of frozen Deuterium was varied ($0-200\text{ cm}^3 / 0-9\text{ mol}$). For smaller quantities of sD_2 (0-4mol) the setup with the premoderator has roughly a gain over 2, compared to the setup without a premoderator. The UCN count rate for the premoderator setup starts to saturate from 4-5 mol on. This behavior is not seen at the setup without a premoderator. This can be explained by the fact, that sD_2 itself acts also as premoderator on the thermal neutrons, but it's not so efficient as Mesithylen or other cold moderators (CD_4 or H_2). Therefore the saturation of the extraction of UCN from the sD_2 is compensated by additional adding of sD_2 at higher sD_2 amount, which act as a premoderator. From the measurements with the premoderator it's possible to extract the averaged mean free path for the UCN inside the sD_2 , which is about 4-5cm.

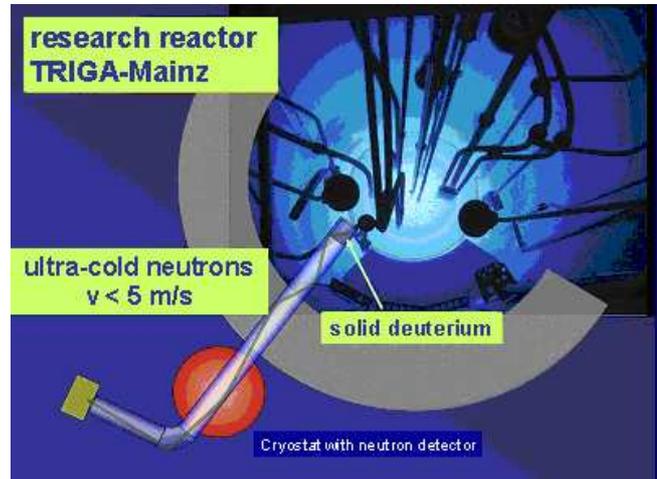


Fig. 1: TRIGA Mainz setup

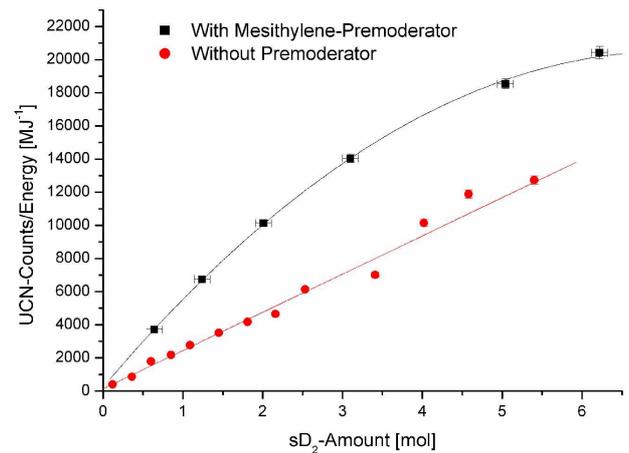


Fig. 2: UCN count rate as function of frozen out sD_2 (with and without premoderator)

The measurement of UCN production at the TRIGA Mainz has demonstrated, that it's possible to use sD_2 as a strong source for UCN. The measured UCN count rates are understood and confirm the theoretical production rates of UCN inside sD_2 . Transforming the results to the situation of having this kind of UCN source exposed to the strong cold neutron flux of the FRMII inside the heavy water vessel shows, that for a typical UCN experiment one can achieve a UCN density of $5 - 10 \cdot 10^3\text{ cm}^{-3}$.

References

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- [2] R. Golub and K. Böning, Z. Phys. **B 51** (1983) 95 – 98