UCN Production with the Upgraded Mark3000 Apparatus

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When cold and thermal neutrons pass through a volume of superfluid helium at very low temperature (ca. 0.4 K), as in the Mark3000 apparatus [1] now set up in the MLL hall II n hole, ultacold neutrons(UCN) of very high density can be produced by one- and multi-phonon processes, respectively, after a long storage time (e. g., 400 s). Since the ^{4}He absorption cross section is zero, the storage time is limited only by the neutron life time, the ^{4}He purity and the storage-volume-wall absorption cross section. High ^{4}He purity and low absorption are obtained by filling the storage volume through a superleak (compressed Al_2O_3 powder with 200 Å grain size) and sputtering the walls with Be, respectively. A Be sputtering device is now being set up.

The UCN production rate densities with one- and multi-phonon excitation are $R_I = d\phi/d\lambda(\lambda^*)(\lambda^*/3)\alpha\, n_{^4He}\sigma_b S_I(\lambda^*)(T_c/T^*)^{3/2}$ and R_{II} $n_{^4He}\sigma_b\sqrt{2E_0}T_c^{3/2}/(3\pi\hbar c)\int_0^\infty d\phi/d\lambda(\lambda)\,\lambda\, S_{II}(\lambda)\,d\lambda$ [2 respectively, where $d\phi/d\lambda$ is the incident spectral flu $\lambda^* = 8.99\AA$ and $T^* = 11.85$ K the n wavelength and e ergy at the crossing point of the free n and the acou tical phonon dispersion curves, respectively. $\alpha = 1.$ is a correction factor due to the dispersion-curve slop at $\lambda^*, n_{^4He} = 2.185 \cdot 10^{22} cm^{-3}$ the ^{4}He atom de sity, $\sigma_b = 1.13 \cdot 10^{-24}$ cm^2 the bound cross sectio $E_0 = 1.09 \cdot 10^{13}$ K the n rest energy, $T_c = 2.73$ mK t critical UCN energy inside the Be coated storage volun filled with helium. S_I and S_{II} are the one- and mul phonon scattering functions, respectively, where S_I is ju a sharp peak with $S_I(\lambda^*) = 0.14\,K^{-1}$ and 0.28 Å widt $S_{II}(\lambda)$ rises sharply from zero at 2 Å to a peak wi $S_{II}(\lambda = 2.8\AA) = 10.6 \cdot 10^{-3}\,K^{-1}$, decreases then to minimum with $S_{II}(\lambda = 5\,\AA) = 3.4 \cdot 10^{-3} K^{-1}$ and rises again slightly.

Positioning the upgraded Mark3000 at the FRM QR2 n guide, $R_I = 0.16\, cm^{-3}s^{-1}$ and $R_{II} = 0.26\, cm^{-3}s^{-1}$ [3], at the end of the FRMII SR4 cold neutron source beam tube $R_I = 3.0\, cm^{-3}s^{-1}$ and $R_{II} = 29.1\, cm^{-3}s^{-1}$ and at the end of the FRMII SR7 thermal beam tube $R_I = 0$ and $R_{II} = 16.4\, cm^{-3}s^{-1}$ result, respectively [4].

In a first test with a reduced storage volume, ca. 1.4 l ^4He could be cooled to 0.6 K together with a 2 x 2 cm^2 Si PIN diode on which an ^{192}Ir β source was attached (cf. fig. 1). The lowest temperature of 0.4 K could not be reached because the ^{3}He circuit heat exchanger, which is coupled to the ^{4}He storage volume, was plugged with oil, thus, reducing the ^{3}He mass flow and cooling power. The heat exchanger has been purified using hexan. The detector worked very well at this temperature. Fig. 2 shows the measured β spectrum. The UCN volume Yoshiki type level meter [5] has been rebuilt (fig. 3).

After sputtering the UCN storage volume walls with Be, one more cooling test is planned and then Mark3000 will be moved to a neutron source in order to measure the achievable UCN density using a newly developed UCN detector [6].

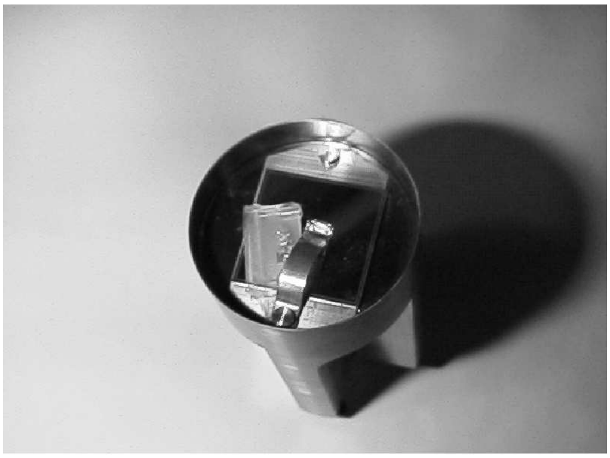

Fig. 1: Si PIN diode detector assembly with ^{192}Ir β source attached

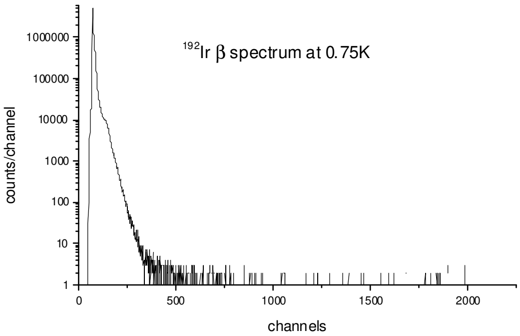

Fig. 2: ^{192}Ir β spectrum measured at low temperature

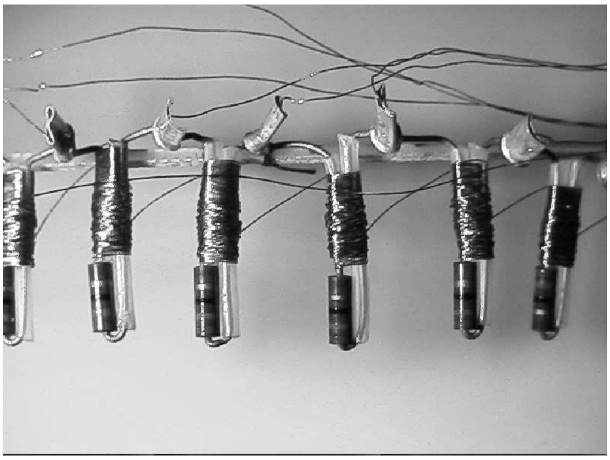

Fig. 3: Yoshiki type superfluid helium level meter. The Allen Bradley resistors and heater windings can be seen

References

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[5] H. Yoshiki, Cryogenics **24** (1984) 704
[6] I. Altarev *et al.*, this report, p.112