TEST OF A PERFECT CRYSTAL NEUTRON STORAGE DEVICE

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Received 27 December 1989; accepted for publication 11 January 1990
Communicated by J.P. Vigier

A system of two perfect silicon crystal plates (1.07 m apart) both placed in back reflection position ((1,1,1)-planes) was used to capture highly monochromatic (6.27 Å) neutrons. We have been able to show that a pulsed magnetic field is a proper means to fill the system with neutrons and to release the neutrons after a period of up to 30 ms. Here we present our first results obtained from measurements at the ISIS pulsed neutron source at Rutherford Appleton Laboratory.

Different methods have been tested for the storage of ultracold neutrons which are based on the neutron bottle and magnetic storage principle [1-3]. In these cases the critical angle for total reflection becomes rather large and the phase space density is rather high depending on the moderator used. The number of stored neutrons is of the order of 10-100 which could have been stored for times larger than the lifetime of the neutron. Nevertheless, most neutron physics applications deal with thermal and cold neutrons and the question of flux increase is a standing problem.

The aim of the present work was the development of a storage system for thermal and cold neutrons which acts as a kind of neutron resonator and which can be used as a basic element for novel beam tailoring methods in the future [4].

A monolithic perfect silicon crystal, 1.07 m long with plates (52×30 mm) at each end is used as a neutron storage system. The crystal is cut in the (1,1,1)-direction so that the neutron wavelength for back reflection is 6.27 Å. To reduce lateral losses we use a 1 m long piece of neutron guide between the two plates which is adjustable in all directions. The neutron guide which has a cross section of 26×40 mm² is of uncovered glass and has a critical angle for total reflection of 24 min of arc. This system has a \( \Delta k/k \) resolution of about \( 4 \times 10^{-5} \) [5]. A sketch of the whole apparatus without the vacuum vessel enclosing the whole storage system is shown in fig. 1. The set-up was installed near the end of the curved neutron guide tube supplying the IRIS spectrometer at a distance of approximately 34 m from the liquid hydrogen moderator of the source.

Because of Zeeman splitting, a magnetic field \( B \) causes a shift of the \( k \)-vector of the neutrons of \( \Delta k = \pm \mu B m/\hbar^2 k \) due to its coupling with the magnetic moment of the neutron \( \mu \). This has been verified experimentally [6] and provides the basis for the operation of gated crystals where the momentum of the neutrons can be shifted relative to the Darwin reflection curve of the crystal causing an open or closed situation [4] (fig. 2).

The system is filled with neutrons by a magnetic pulse of approximately 1.3 T (1.26 T causes a shift of the reflection curve equal to the width of its plateau) applied at the first crystal plate. The neutrons can be released from the system by applying a magnetic pulse at the second crystal plate. The whole duration of the magnetic pulse was 1.2 ms whereas the time-of-flight of the neutrons between the crystal