Neutron-optical image obtained by using ultracold neutrons

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We obtained a neutron-optical image of a UCN source by using a cylindrical mirror after multiple reflection of UCN from two, plane-parallel horizontal mirrors. The image was recorded as parallel bands on a glass plate, which was used as a solid-state track detector.

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To determine the neutron charge using ultracold neutrons (UCN), it was suggested[1,2] that the displacement of the neutron-optical image of a UCN source, which was produced by placing a circular cylindrical mirror in an electrical field, should be used. In view of this, experiments were carried out to determine the possibility of obtaining such images.

The experiments were performed using the SM-2 NIIAR reactor at Dimitrovgrad.

Figure 1 shows a diagram of the experimental setup, consisting of a UCN source 9, a detector 8, two plane-parallel horizontal mirrors 1 and 2, a vertical circular cylindrical mirror 3, and latteral polyethylene absorbers 4 and 5 with a vacuum casing (not shown in the sketch). The source 9 and the detector 8 are placed side by side, and the cylindrical mirror is oriented in such a way that its O–O' axis is located at the center between them.

The horizontal mirrors and the cylindrical mirror are made from 12-mm-thick boron-free silicate glass. The horizontal mirrors are 250 mm long and 154 mm wide. The radius of curvature of the cylindrical mirror is $R = 238$ mm, its height (width) is 20 mm, and the length of its working area is $d = 58.5$ mm. The UNC source consists of four 22-mm-high vertical slits. The widths of the slits and the spacing between them are shown in Fig. 2b.

The ultracold neutrons with velocities $v < 3$ m/sec, which are admitted into the

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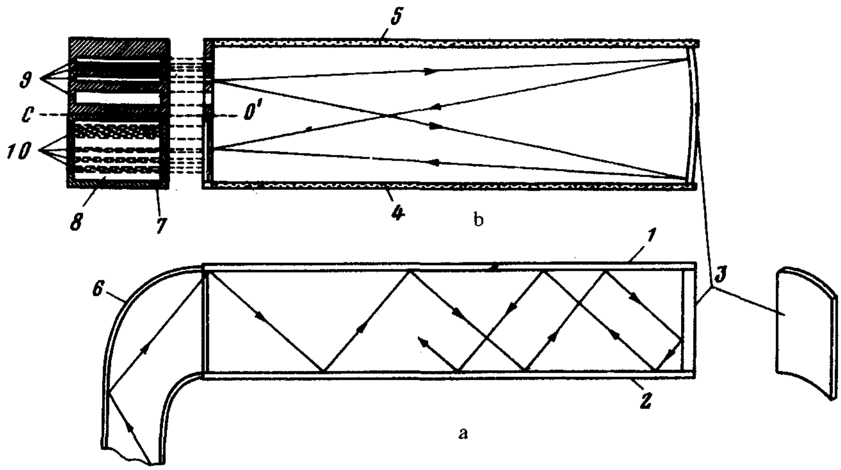

FIG. 1. Diagram of the experimental setup: a—side view; b—top view.

volume at different angles after multiple reflections from the surfaces of the horizontal plane-parallel mirrors and a single reflection from the cylindrical mirror, converge at the surface of the detector, producing an image of the source. We used a UCN track

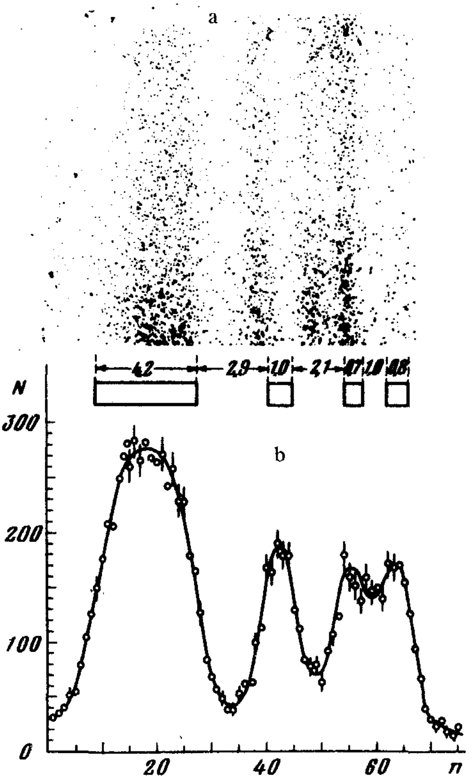

FIG. 2. a—Photograph of the neutron-optical image of the source; b—curve for the density variation of the tracks in the transverse direction. (The channel number is plotted along the X-axis and the number of tracks per channel is plotted along the Y-axis. The widths of the slits and the distance between them are in millimeters).

detector[3] that consists of a uranium-titanium radiator[4] and ordinary photographic glass. The total efficiency of the detector for UCN was about 5–6%. The exposure time was 72.5 hours. After processing the glass with a 5% aqueous solution of hydrofluoric acid for 15 minutes at 20 °C, an image of the slits in the form of parallel bands visible by the naked eye appeared on the surface.

Figure 2a shows a photograph of the neutron-optical images and Fig. 2b is a graph of the variation of the density of the tracks on the glass in the transverse direction of the slits. The tracks were counted under a microscope with a magnification of 100 and a "channel" width of 0.225 mm.

The neutron-optical images appeared in the same places as the images obtained by using light. This indicates that the UCN travel strictly according to the laws of geometrical optics.

As seen in Fig. 2b, the width at half height of the large peak with fewest coincidences is equal, within the limit of error, to the width of the corresponding source slit. It can also be seen that the resolution of the apparatus is of the order of 1 mm.

In conclusion we can say that the quality of the obtained neutron-optical images is entirely satisfactory from the point of view of the set goal.

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