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Reflector Optimization for Coupled Liquid Hydrogen Moderator

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ABSTRACT
As a part of optimization studies on a coupled liquid hydrogen moderator system, the optimal thickness of the reflector, the effects of neutron absorbing liners and other beam hole/moderator on the cold-neutron-beam intensity were studied experimentally. It turns out that the optimal thickness is rather thick in this system and the existence of Cd liners around the beam extraction hole considerably reduces the cold neutron beam intensity, while the existence of other beam hole and moderator does not give an important intensity reduction.

I. INTRODUCTION

In a coupled liquid-hydrogen-moderator system the role of reflector is to supply thermal neutrons to liquid hydrogen, while in a decoupled system to supply fast and epithermal neutrons. So far the reflector studies have been done only for the decoupled moderator system. We therefore studied experimentally the reflector effect on the cold-neutron-beam intensity in a coupled liquid-hydrogen-moderator system in order to obtain better understanding of the reflector effects. We measured the neutron-beam intensities from the coupled liquid-hydrogen-moderator proposed in the preceding report[1] with various reflector configurations.

II. OPTIMAL REFLECTOR THICKNESS

To find the optimal reflector thickness we performed measurements in two steps. Firstly, we examined the effect of the rear-upper-reflector. The premoderator thickness was fixed to 2 cm (optimal thickness). Figure 1 shows the neutron-beam intensity at three different energies as a function of reflector thickness of the part indicated in the inset. The reflector thickness of the lower half (below the target) was kept at 40 cm. The intensities are saturated at a thickness of about 40 cm, independent of neutron energy. The required thickness is rather large compared to a decoupled moderator system.

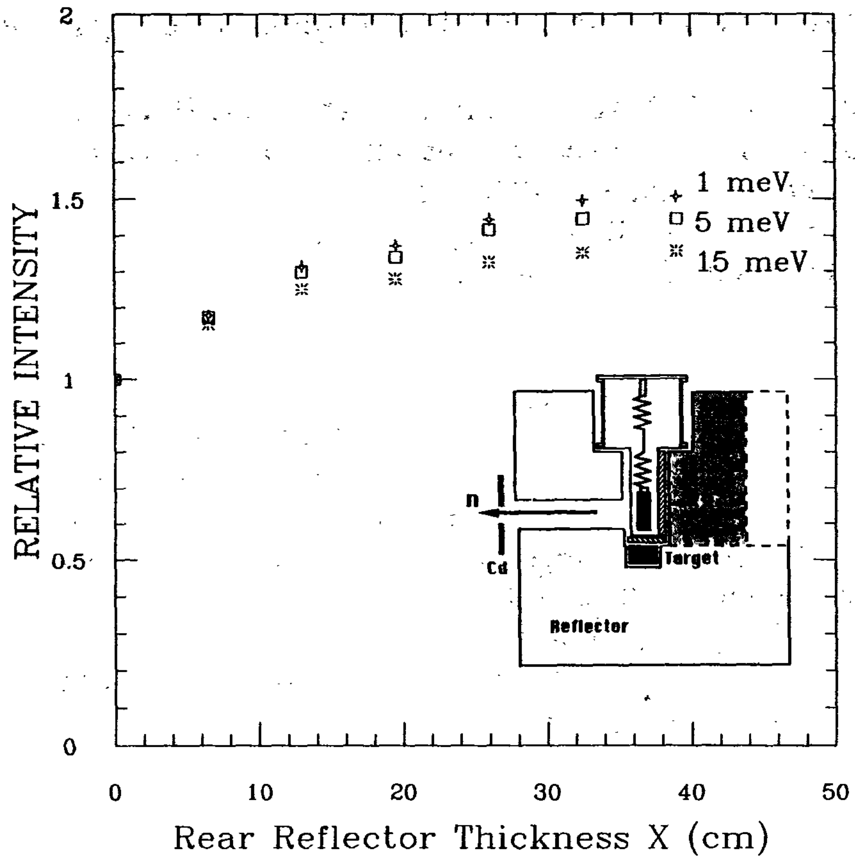

Fig. 1 Effect of the rear-upper-reflector thickness on the neutron-beam intensity. The part of reflector changed is shown in the inset.

Secondly, we examined the effect of the upper reflector. Figure 2 shows the measured neutron-beam intensities as a function of the upper reflector height (see the inset). For longer wavelength neutrons the intensity is still increasing even above 40 cm. This is probably due to the reflector missing caused by the cryogenic void. In a real system the void space produced by liquid hydrogen piping above the moderator chamber would be smaller than that of the present cryostat. However, a thicker upper reflector is important for a coupled liquid-hydrogen-moderator system.

III. EFFECT OF OPENING ANGLE OF BEAM EXTRACTION HOLE

In the KENS-II program it is strongly requested to provide as many neutron beam channels as possible[2]. For this requirement the larger opening angle of the beam extraction hole in the reflector becomes indispensable. We therefore examined the effect of the opening angle on the slow neutron

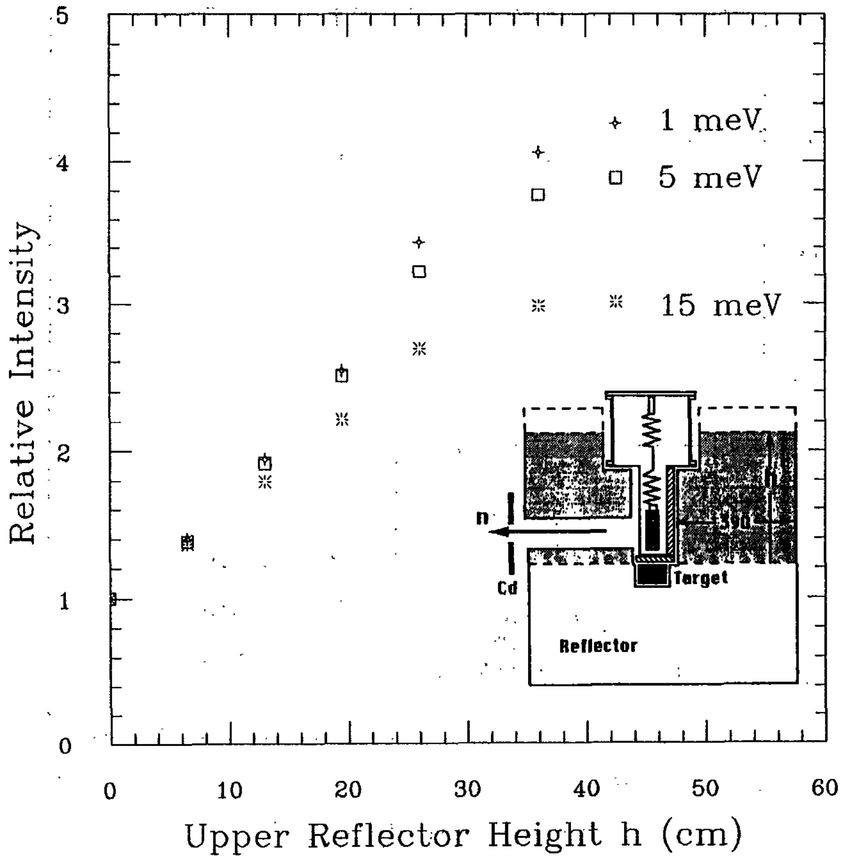

Fig. 2 Effect of upper reflector height on the neutron-beam intensity. The part of reflector changed is shown in the inset.

intensity. Figure 3 shows the intensity of slow neutrons emitted parpendicularly from the moderator surface as a function of the opening angle (see the inset). The reduction in the neutron-beam intensity is rather small (only 3-5 % even at 30°) and independent of neutron energy. In the present experiment we studied only one half of the opening angle, but the intensity reduction in the case of a symmetric opening would be less than the double in the half opening case. The intensity of slow neutrons emitted to the direction not perpendicular to the moderator surface, of course, decreases with emission angle θ as $(1+\sqrt{3}\cos\theta)/(1+\sqrt{3}/2)$ in addition to the reflector effect.

IV. EFFECTS OF Cd LINER, ANOTHER BEAM HOLE AND MODERATOR

We examined the various effects such as front-premoderator, the cadmium liner around beam extraction hole in the reflector and existence of another beam extraction hole, on the cold-neutron-beam intensity. Figure 4 shows the moderator-reflector configurations studied. The observed cold-neutron-beam intensities are summarized in Table I. We chose the configuration (a)

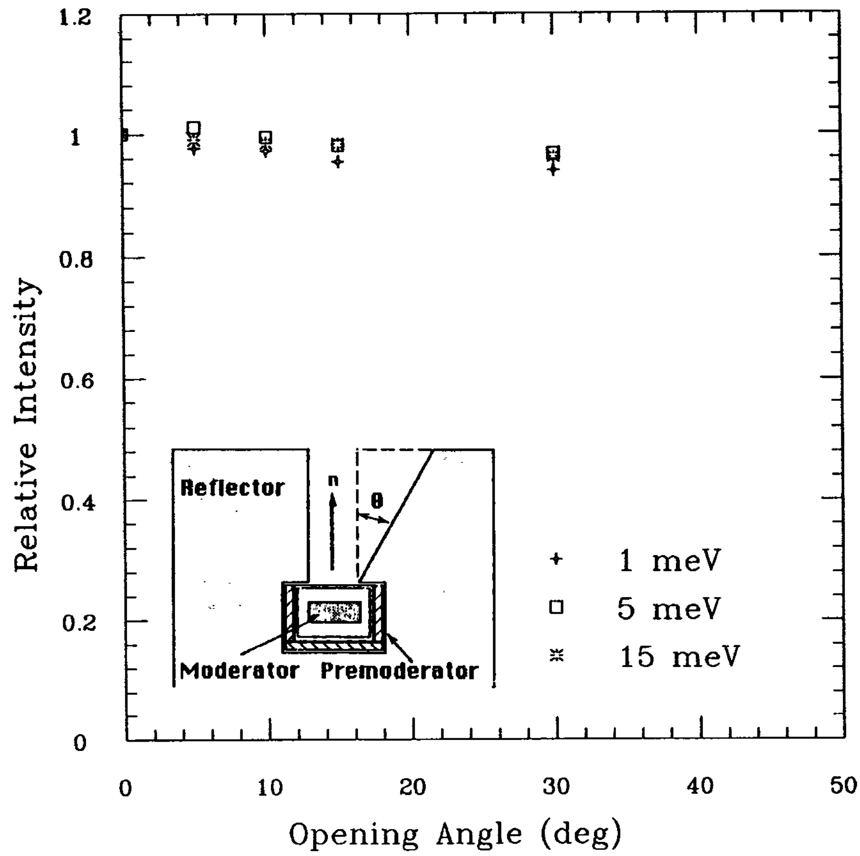

Fig. 3 Effect of the opening angle of the beam extraction hole on the neutron-beam intensity.

as a reference since it gave the highest intensity. The values in the table are the relative ones to the configuration (a).

By removing the front-premoderator (configuration (b)) we have about 12 % reduction in the beam intensity. By inserting a cadmium liner around the beam extraction hole (configuration (c)), about 40 % reduction comes out in total. The insertion of another cadmium mask in place of the front-premoderator (configuration (d)) results in the beam intensity reduction of about 50% in total.

Usually several moderators of different kinds, some are decoupled and others are coupled, will be placed around the target. Each moderator has beam extraction hole(s) on one side or both sides of the moderator. The introduction of another beam hole will bring about an additional reflector missing. We examined the case of two holes. For simplicity we made a second hole in the opposite side of the first one (configuration(e)). The size of the hole is 17×17 cm^2. This brings about 7 % loss in the beam intensity compared to the configuration(b). The insertion of a cadmium liner in the second hole (configuration (f)) gives almost no effect. The fact means that the neutrons with energies below Cd cut-off bring little effect on the cold-

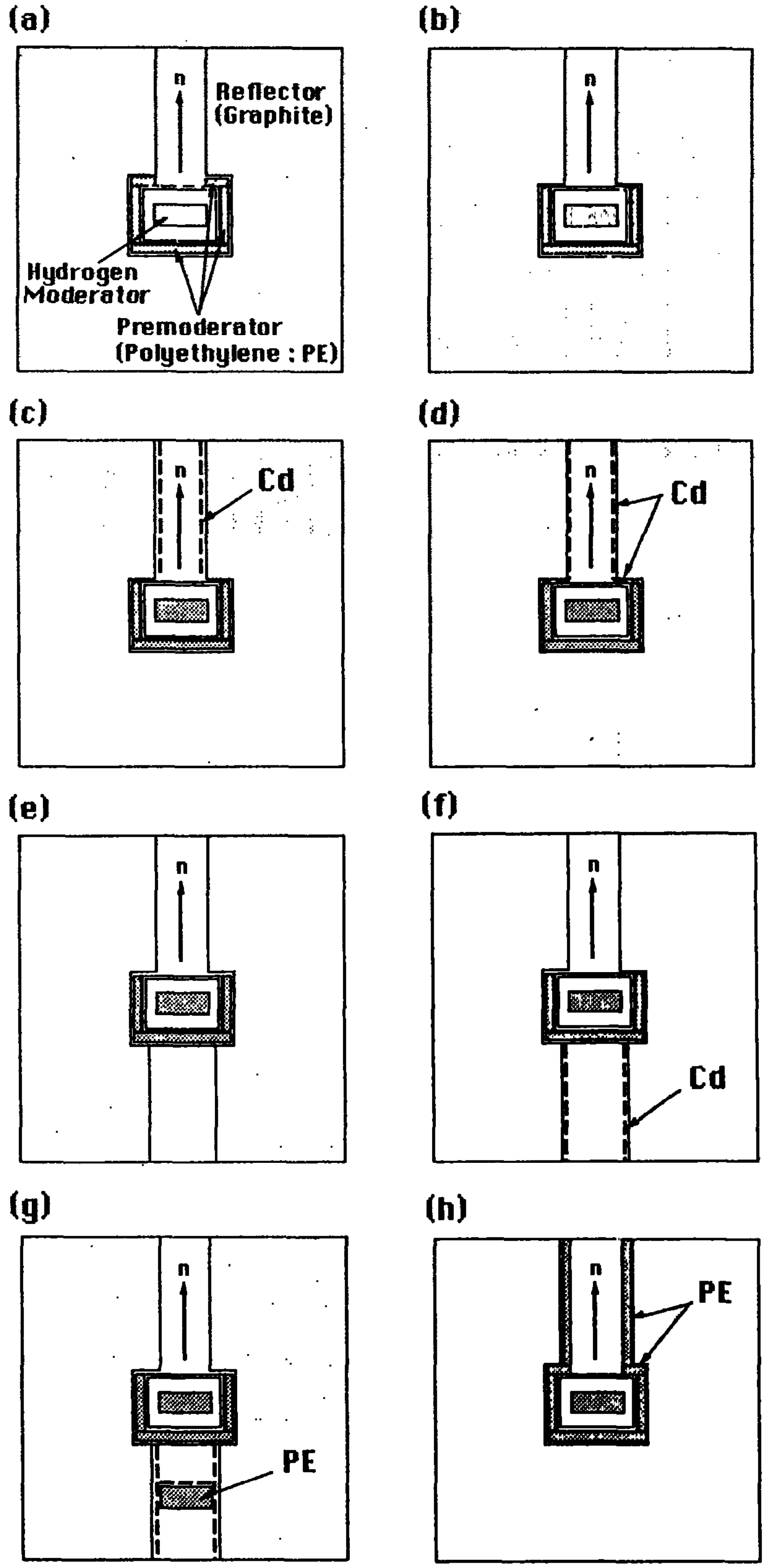

Fig. 4 Various moderator-reflector assemblies studied.

Configuration	Relative intensity to configuration (a)
(a)	1.00
(b)	0.88
(c)	0.62
(d)	0.52
(e)	0.81
(f)	0.78
(g)	0.74
(h)	1.05

Table 1 Relative intensities from the moderator-reflector assemblies shown in Fig. 4.

neutron-beam intensity. This is a great contradiction to the results obtained from the configuration (c) and (d). The reason is not understood at this moment.

In order to simulate the effect of other moderator we put a decoupled polyethylene moderator 15x15x5 cm^3 (at ambient temperature) in the second hole (configuration (g)). This does not give an appreciable reduction. The present results suggest that a coupled liquid-hydrogen-moderator with a premoderator can coexist with other decoupled moderators in the same target-moderator-reflector assembly.

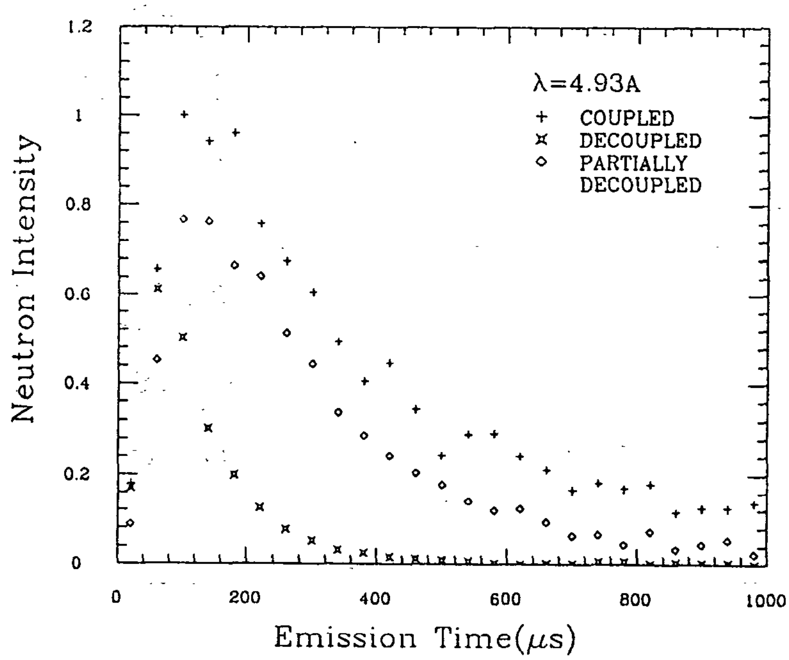

Fig 5 Time distributions of cold neutrons from the partially decoupled moderator (configuration (d)).

As an extra we examined the configuration (h) where a 1.5 cm-thick polyethylene liner was attached to the extraction hole. This configuration gives the highest beam intensity, but the obtained gain is small.

In order to understand the reason why the intensity reduction in the configuration (d) is so large, we measured time-distribution of the cold neutrons from the moderator in configuration (d). In Fig. 5 is plotted the measured time distribution of cold neutrons compared with the coupled and decoupled moderators. The pulse height and width in configuration (d) lie between both.

ACKNOWLEDGEMENTS

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REFERENCE

1 Y. Kiyanagi, N. Watanabe, M. Furusaka, H. Iwasa and I. Fujikawa : Proc. ICANS-XI (1990) p-388.
2 N. Watanabe : Proc. ICANS-XI (1990) p-471.

Q(P.A.Egelstaff): Have you tried using a heavy element with a large scattering cross-section as the reflector?
A(Y.Kiyanagi): A heavy element with a large scattering cross-section is an effective reflector for a decoupled moderator system. A moderating material is probably more suitable for a coupled liquid hydrogen moderator because slow neutrons should be fed to the liquid hydrogen moderator.