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FURTHER OPTIMIZATION OF COUPLED LIQUID-HYDROGEN MODERATOR FOR INTENSE PULSED NEUTRON SOURCE

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ABSTRACT

Optimization studies for increasing cold neutron intensity from a coupled liquid-hydrogen moderator with a premoderator were performed. Optimal thickness of hydrogen moderator was found to be 5 cm. A beryllium (Be) reflector-filter placed in front of the moderator chamber gave almost no intensity enhancement in a cold neutron region. Narrow beam extraction was effective for some instruments which view a small area of the moderator surface. Beam intensity decreased a little by extracting neutron beams from both sides of the moderator in comparison with a single beam extraction.

1. Introduction

A composite moderator (liquid-hydrogen with hydrogenous premoderator) is now well known to be the best candidate for intense pulsed neutron source due to its high efficiency[1]. In order to have more intensity we experimented by making some modifications to this moderator system.

Our previous experiment shows that the cold neutron intensity from the composite moderator which had 2 cm thick liquid-hydrogen was lower than the one which had 5 cm[2]. This suggests that the thickness of 5 cm for the main cryogenic moderator (liquid hydrogen) may not be optimal. Therefore, it is interesting to check thickness dependence of the cold neutron intensity. We measured the cold neutron intensity from moderators with three different thicknesses to examine the thickness dependence.

We thought another approach for increasing intensity would be to examine the effects of a Be reflector-filter in front of the viewed surface of the liquid hydrogen moderator. It was reported that for a bare moderator system this method brought about a gain factor of 1.7-2.2 depending on the Be thickness (2-4 cm)[3]. Therefore, it would also be interesting to study whether this method is also useful for the composite system for increasing intensity. We performed a measurement of the cold neutron intensity from the composite moderator system with a Be reflector-filter.

Spatial distribution of cold neutrons from a coupled composite moderator in wing geometry was found to be have a brightest region near the target. Therefore, this distribution is useful for small angle neutron scattering, reflectometry etc., in which only a small part of the moderator is viewed by those instruments. Thus, the following idea emerges, that is, the cold neutron intensity can be increased to some extent if the remaining part of the moderator is covered by an additional premoderator. We looked into this idea.

Keywords: Pulsed Neutron, Liquid hydrogen, Cold neutron, Intensity

In actual application of this kind of moderator, it may be interesting to know how the neutron intensity decreases if the neutron beams are extracted from both sides of the moderator. We also studied this effect experimentally.

2. Experimental set-up and results

Experimental set-up is essentially the same as the previous one[1]. In the thickness dependence study, composite moderators with 2, 5 and 6.5 cm thick liquid hydrogen were measured. The lateral dimension was 12 cm x 12 cm. A light water premoderator of 2 cm thickness was used. Figure 1 shows measured results. The moderator system is shown in the inset. The cold neutron intensity is almost saturated around 5 cm thick. The present result is a lot more different from the bare and decoupled moderator case[4]. This is due to the nature of the composite moderator: since the neutrons flowing into liquid hydrogen are well moderated by the premoderator, adding more hydrogen does not produce more cold neutrons but in fact decreases them.

In the Be reflector-filter experiment, liquid hydrogen of 5 cm thick was used. As a Be reflector-filter a 1.5 cm thick Be plate (lateral dimension: 10 cm x 10 cm) was attached to the main cryogenic moderator chamber (see Fig.2). Therefore, the temperature of the Be plate was about 20K. Figure 2 shows spectral intensities from this moderator system with and without the Be reflector-filter. There is no additional gain in the cold neutron region by introducing Be. We were not expecting such a result. However, the present result was natural if we consider that this system is already well reflected and the insertion of additional reflecting material simply screens thermal neutrons flowing into liquid hydrogen.

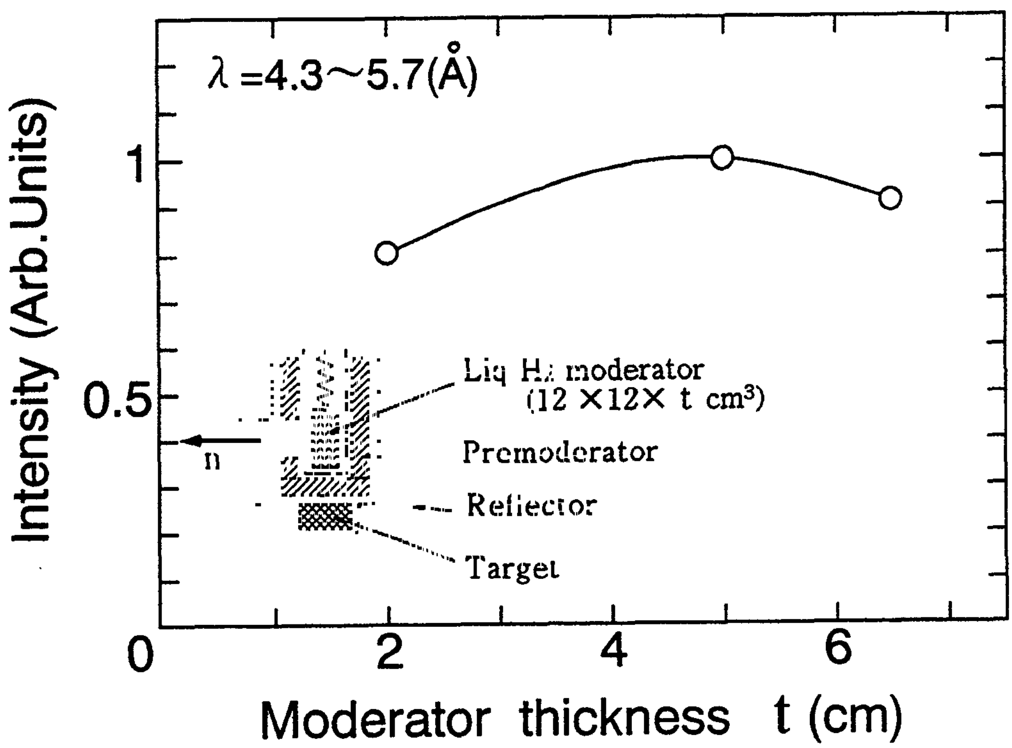
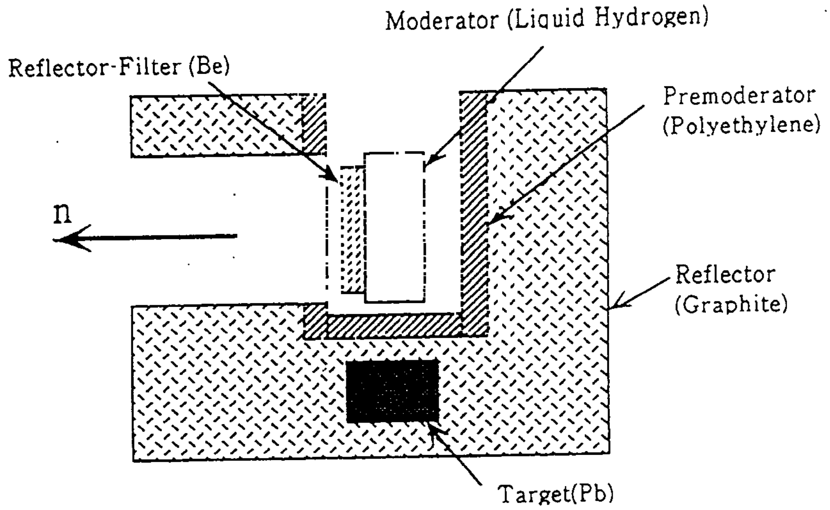


Fig. 1 Cold neutron intensity vs. thickness of liquid-hydrogen moderator. The composite moderator examined is shown in the inset.

The spatial distributions of cold neutrons were measured over the brightest region 0.5-4.0 cm from the moderator bottom, with and without the additional premoderator, by moving a Cd slit with 0.5 cm high and 8 cm wide. The moderator systems studied here are shown in Fig. 3. The results are shown in Fig. 4. The gain with an additional premoderator is about 15%. This situation was almost unchanged by introducing a beam hole on the opposite side.



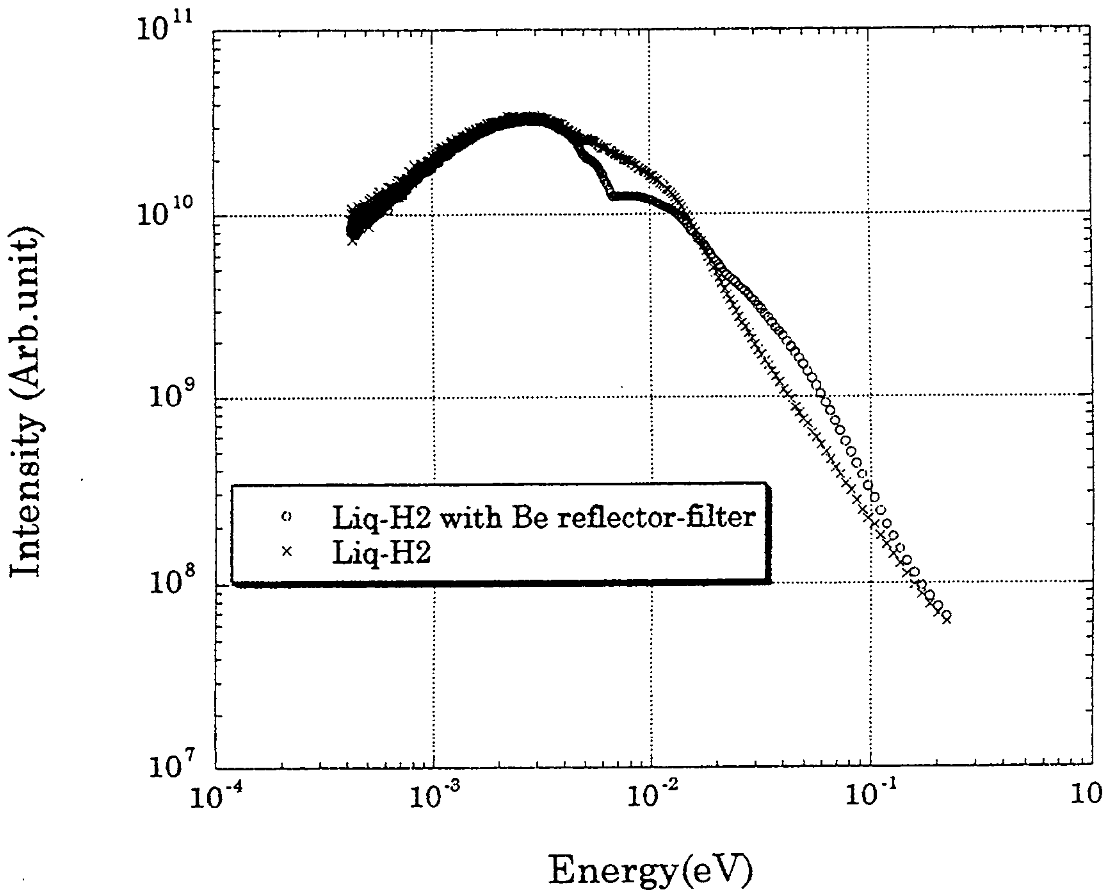


Fig. 2 Energy spectra from a composite liquid-hydrogen moderator and from the same moderator with Be reflector-filter. The moderator system with Be is also shown.

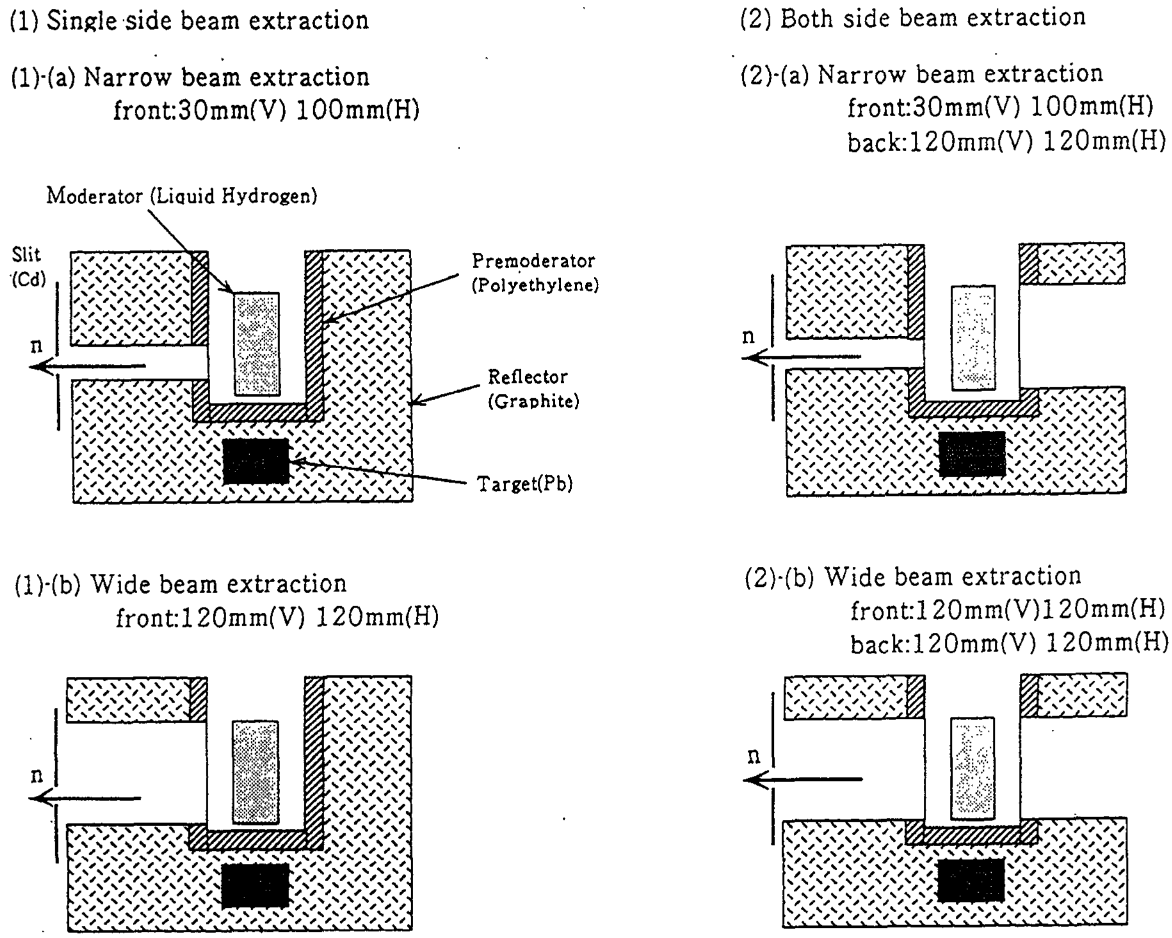


Fig. 3 Moderator systems used for narrow beam extraction experiments. Single and double beam extractions were examined. As a reference a moderator system with a wide beam hole of a size commonly used was also studied.

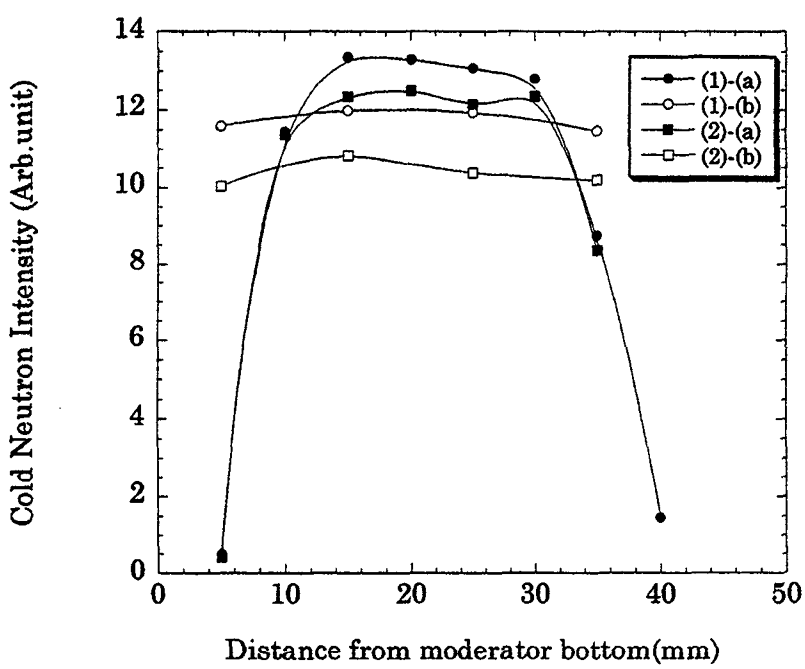


Fig. 4 Spatial distributions of cold neutron intensities along the vertical direction from the bottom of the moderator.

Finally, we measured the decrease of cold neutron intensity by extracting neutrons from the opposite side of moderator (see Fig. 3(2)). If the premoderator of the opposite side in Fig. 3(1)-a is removed and a standard straight beam extraction hole (12 cm x 12 cm) is opened in the reflector (see Fig. 3(2)-a), the intensity decreases by about 6%. This decrease would be acceptable. Next, if the premoderator of the opposite side in Fig. 3(1)-b is removed and the standard beam hole is opened (see Fig. 3(2)-b), the intensity decreases by about 12%.

3. Conclusion

The optimal thickness of hydrogen moderator to obtain the highest cold neutron intensity from a composite moderator system was found to be about 5 cm. A reflector-filter was not effective to increase the cold neutron intensity in this system. Partial enhancement of the cold neutron intensity could be achieved by narrow beam extraction, which is useful for small angle neutron scattering, reflectometry and so on. Beam extraction from both sides of the moderator causes very small reduction in intensity. So, it would be better to use this type of beam extraction than to equip two moderator systems for individual beam extraction.

We are now planing to examine a composite moderator with a grooved hydrogen moderator which extracts cold neutrons from the deep part of the moderator where neutron flux is high.

4. References

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