Large Analyser Mirror Low-Energy Spectrometers, LAM(KEK) and LANDAM(HU), and Electron Linac Cold Source

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The spectrometers, the LAM(KEK) and its prototype LANDAM(Hokkaido University), are suitable to measure the low energy transfer neutron scattering. They were planned mainly to be used in the studies of diffusive motion in condensed matter with conventional energy resolution. The accelerator-based cold neutron source was chosen for the features; its nearly flat distribution of the time-of-flight spectra and its ability to achieve a very low background level. These features are particularly advantageous in quasielastic experiments using a conventional energy resolution in which analyses of the quasielastic peak shape, and not only the peak width, are required. Figure 1 shows the cold neutron time-of-flight spectrum emanating from the 20 K methane cold source and the spectrum from ambient temperature water. The same size moderator chamber was used. The spectrum from methane exhibits enhancement and a nearly flat distribution of around 5 meV. Figure 2 shows the time-energy distribution, the typical time constants of the pulse; the rise time, half-width and decay time. The rise time is about 20 μsec and it does not vary appreciably as a function of energy.

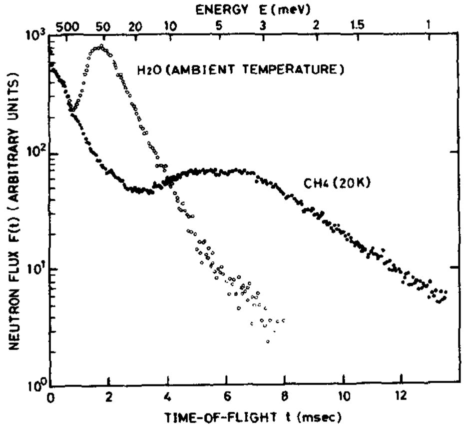


Fig. 1. Measured neutron time-of-flight spectra from a 20 K methane moderator and an ambient temperature water moderator.

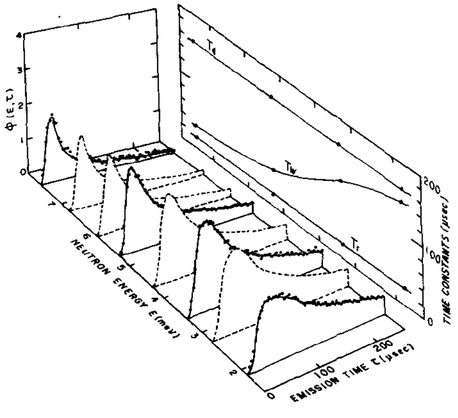


Fig. 2. Time dependent neutron flux emanating from a 20 K methane moderator. The experimental results are shown by the dots, and the synthesized curves are indicated by the smooth curves.

Figures 3 and 4 are the plane view of the LAM and the LANDAM, which are inverted geometry tof spectrometers. As illustrated in Fig. 5 the spectrometer consists of the cold source at distance ℓ_1 from the specimen and a set of four assemblies of large area crystal analyser mirrors, beryllium filters, and counters. The spectrometer operates as follows: neutrons are scattered through the second flight distance ℓ_2, they are reflected by the analyser mirrors, impinge on the beryllium filters, and subsequently are detected by the counters as monochromated neutrons.

Untill now, many quasielastic investigations have been dominated by measurements of energy-gain scattering, and the scattered neutron spectra observed by time-of-flight spectrometers have been considerably distorted by the time factor t^{-3} weighting factor in the time-of-flight which inevitalby appears in ordinary direct geometry facilities. When inverted geometry is employed, this large spectral distortion is eliminated because of the nearly flat distribution of the cold neutron time-of-flight spectrum as shown in Fig. 1.

We were able to estimate the resolution of the spectrometer in an

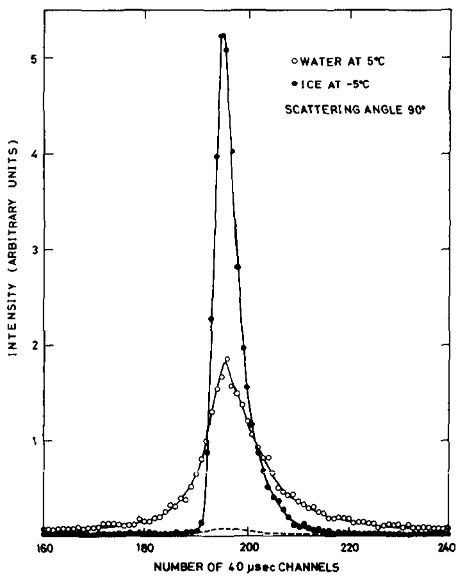


Fig. 6. Raw data of normalized scattered intensities from water at 5°C and ice at -5°C at 90° scattering angle. The dashes indicate the background counts.

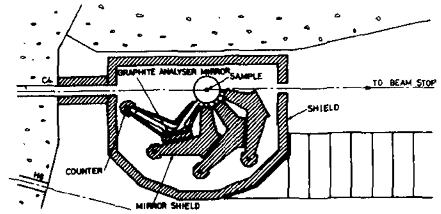


Fig. 3. Plane view of the LAM spectrometer

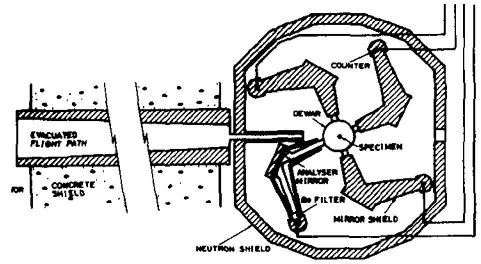


Fig. 4. Plane view of the LANDAM spectrometer

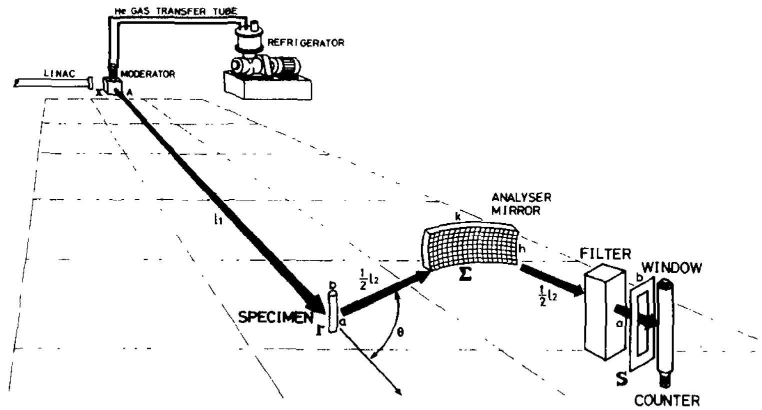


Fig. 5. General layout of the quasielastic spectrometer using an accelerator cold neutron source. Cold neutrons are produced by a methane slab moderator at 20 K.

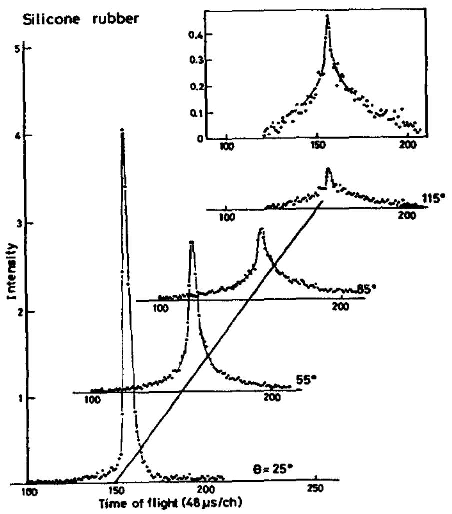


Fig. 7. Quasielastic peaks of silicone rubber at four angles at ambient temperature by LAM.

experiment on the scattered intensity of ice (Fig. 6). The rise time of the peak for the pure elastically scattered neutrons was short, and its shape, which appeared on the rising side, was nearly the same as that of the resolution function of the analyser mirrors. The decay time was relatively long, owing to the properties of the incident neutrons.

These spectrometers show high efficiency. One paint in fact is that for the count rate of the same sample, the LAM is almost exactly 10 times more efficient than the LANDAM. However, in comparing their cold neutron yields per one pulse, the KENS cold source yield is about 500 times higher than the LANDAM's.

Figure 7 is the scattered spectra from silicone rubber obtained from the LAM during its initial operation period. The sharp peak is caused from the stationary part in the correlation function which corresponds to the presense of the bridge in rubber polymer and indicates the oscillatory tendency as a

function of Q. This tendency may relate to the dynamical structure of the micro-Brownian motion of the polymer segments between the bridges. In another experiment by using the LANDAM we measured the spectrum of deuterium substituting methanole and its aqueous solution at ambient temperature. Although Fig. 8 is only the raw data, two components due to translational and localized motion were observed. From our data we concluded the localized diffusive motion of hydrogen in hydroxyl becomes restricted. We are continuing our investigations in this area.

The pulsed cold neutron source quasielastic spectrometers described herein have performed effectively under the experimental conditions we have imposed, and it has shown much promise as reliable instruments for application in quasielastic studies where conventional energy resolution is involved.

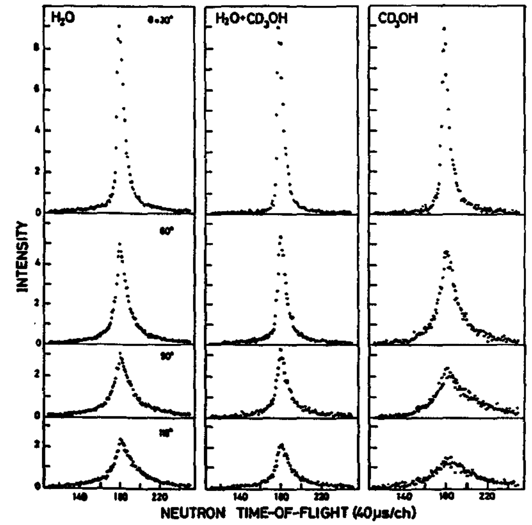
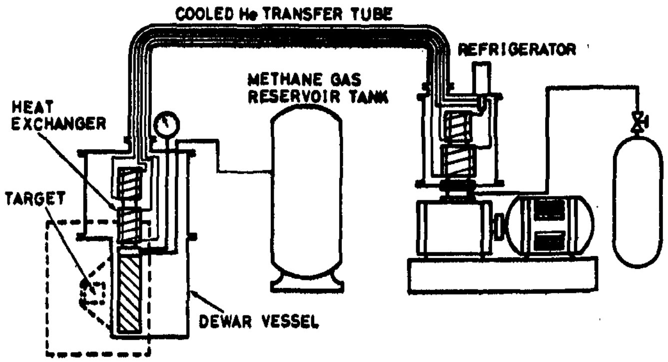


Fig. 8. Quasielastic spectra from water, deuterium substituting methanol and its aqueous solution.



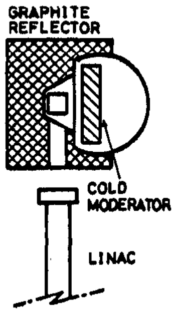


Fig. 9. Flow diagram of the cold neutron source at Hokkaido University.

Electron Linac	35 MeV. 1 KW
Target	tungsten
Cold moderator	methane 20 K
Fast reflector	graphite
Moderator chamber	5x25x25 cm^3 Al
Refrigerator	Philips PEH-100

The signal-to-background ratio is extremely good due to the pulsed source, and the spectral distortion is very small due to the inverted geometry and the cold source spectra. The energy resolution of about 100 ∿ 200 μeV is attainable with reasonable count rates; and the Q ranges are between 0.5 ∿ 2.5 $Å^{-1}$. These spectrometers may also be of value in the performance of peak profile analyses in quasielastic studies.

The cold source at Hokkaido University was developed to be used in a modest capacity electron linac of 35 MeV and 1 KW beam power under operational conditions. In order to accommodate the modest fast neutron source, we had

to develop an efficient cold source. According to several preliminary experiments we chose 20 K methane for the cold moderator. Finally it was demonstrated that the methane was very suitable as a cold moderator for the accelerator-based cold source. The flow diagram (Fig. 9) shows the cold source at Hokkaido University. The simplicity of design and our use of methane render the cold source fail-safe and fail-operative. Decomposition of methane occures during irradiation and the hydrogen production rate is 3.5 % per 1000 hr irradiation. This facility is effectively used as the cold source of the LANDAM spectrometer.