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Present Status and Future Program of KENS

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Abstract

KENS has been operated without any trouble for one year, and been open to all users in Japan from April 1981. Present paper describes present status of machine operation, research activity at KENS, spectrometers and their performances with experimental results already achieved, and future program of KENS-I' and KENS-II. KENS-I' is a project to increase the effective neutron beam intensity one order of magnitude in near future by means of the improvement of the present machine. KENS-II is a big future project which can provide hundred times higher beam intensity than KENS-I. Discussions for it have just started.

§1 Present Status of Operation

The KEK booster synchrotron has been operated successfully since the last ICANS meeting and has delivered 500 MeV proton beam to the neutron experimental facility and also to the meson facility as shown in Fig. 1.

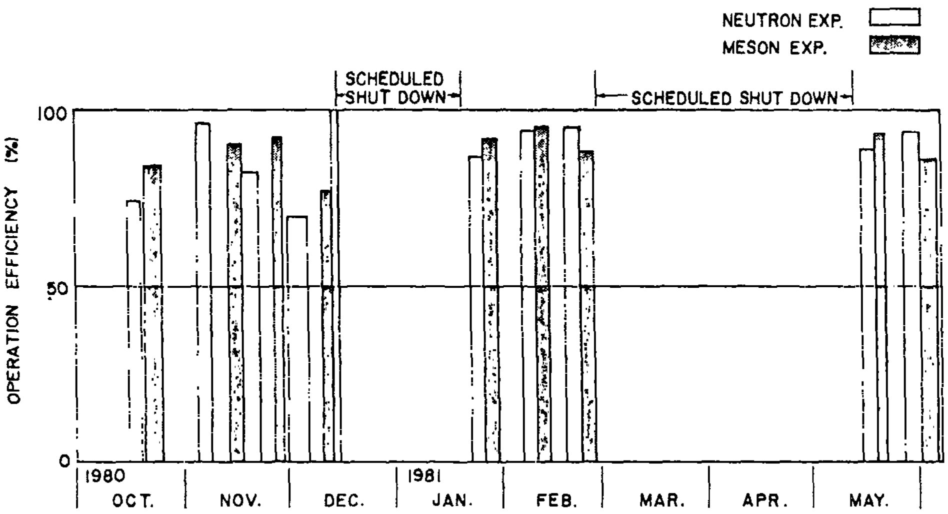

Fig. 1 Operation diagram

Neutron target as well as the cryogenic moderator have been operated without any trouble. The beam intensity of thermal neutrons obtained from the polyethylene moderator at ambient temperature is about 1.4 x 10^6 $n_{th}/cm^2 \cdot$ sec at the beam hole exit (4 m from the moderator). The solid methane moderator has been operated at 18.3 K and provided cold neutron beam of about 6 x 10^5 $n_c/cm^2 \cdot$sec at 4 m position from the source and about 1 x 10^5 $n_c/cm^2 \cdot$ sec at the guide tube exit, in the time averaged values.

A remote exchange machine for the polyethylene moderator which is located below the target has been installed and has successfully changed the spent moderator to the new one.

§2 Research Activity

The KENS facility has been open to all users in Japan from this fiscal year (1981, April) and two types of proposals were accepted. One, Type I, is a project research which makes a big research group installing a spectrometer at a beam hole, while the other one, Type II, is a small research program which provides only the samples and uses the spectrometer already installed. Nine proposals are accepted as Type I (A and B, by KENS classification). They are listed in Table I.

Except RAC, all other proposals are continuation from the last year. As far as the Type-II proposals are concerned, twenty proposals are presented, in which eight proposals were accepted and all the others are on the waiting list. Since the total machine time is devided into two between the neutron and meson groups. We have already a serious problem of shortage of the neutron machine time.

Table I List of Type I Proposal

Group Name	Spectrometer	Classification	Number of Researchers
HIT	HIT	B1	11
LAM	LAM	B1	9
MAX	MAX	B1	5
SAN	SAN	B1	11
TOP	TOP	B1	9
PEN	PEN	A	9
FOX	FOX	A	5
UCN	Ultra Cold Neutron	A	6
RAC	RAC	A	5

§3 S!ectrometers and Their Performances

3.1 HIT

HIT is the total scattering spectrometer constructed to measure the precise structure factor, S(Q), of liquids and amorphous solids over a wide range of momentum transfer ($Q = 0.1 - 100\ A^{-1}$) at a higher rate of data collection[1]. The machine has fifty ^3He counters and is equipped with a sample changer which can accomodate up to six different samples. Lower angle detector banks ($2\Theta = 2 \sim 5°$) composed of annulus ^6Li glass scintillator will be equipped in this fiscal year, which are useful for Placzek correction and also provide useful data at lower Q ($Q_{min} \sim 0.05\ A^{-1}$).

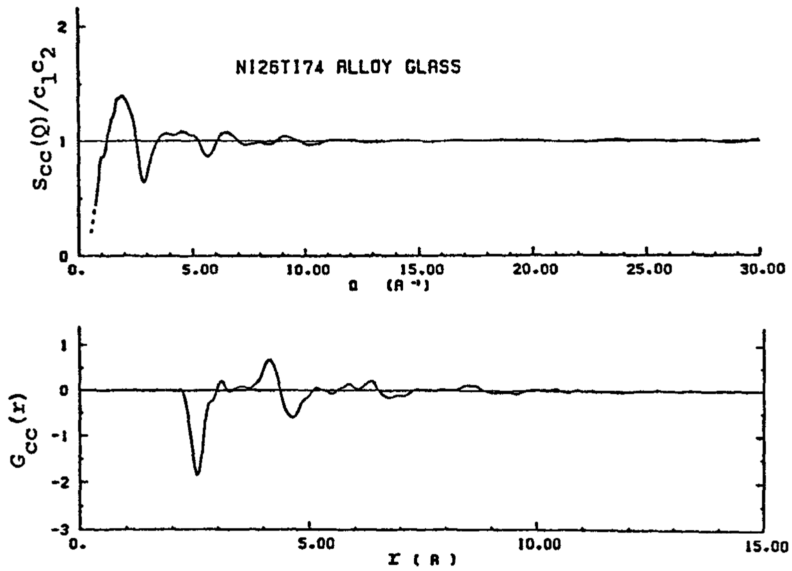

Fig. 2 $S_{cc}(Q)$ and $G_{cc}(r)$ of Ni-74at%Ti zero alloy glass

Metal-metal alloy glasses such as Pd-Zr, Cu-Ti, Ni-Zr, and Ni-Ti systems have already been measured. Particularly neutron zero alloys (<b> = 0) are interesting to make a direct observation of pure concentration-concentration correlation,. $S_{cc}(Q)$, that is the chemical short range order between unlike atoms. The observed $S_{cc}(Q)$ and transformed $G_{cc}(r)$ of Ni-74at%Ti zero alloy glass are shown in Fig. 2, which indicate that the chemical short range order clearly exists in metal-metal alloy glass[2]. HIT can perform these kinds of measurements quite easily which are very much difficult to do with the conventional method.

Higher data collection capability of the HIT makes it possible to measure many samples covering a wide range of compositions, and high Q capability can provide a highly resolved space correlation. Based on these advantages of the HIT, deuterium absorbed metal-metal alloy glasses were extensively studied in a wide range of deuterium concentration. In Fig. 3 are depicted the G(r) for $Pd_{35}Zr_{65}D_{17}$ compared with those for $Pd_{35}Zr_{65}$ glass[3]. Extra peak is clearly observed at small r in the deuterium absorbed sample which corresponds to the metal-deuteron correlation in this glass. Systematic studies are under progress.

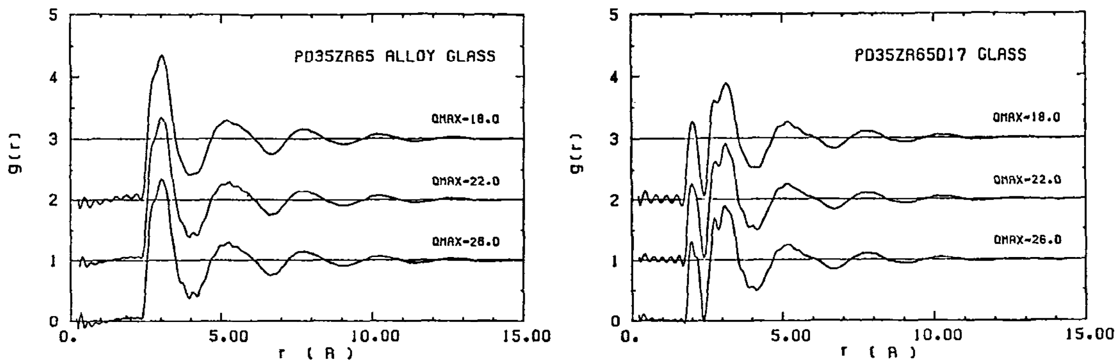

Fig. 3 G(r)'s for amorphous $Pd_{35}Zr_{65}D_{17}$ (left) and $Pd_{35}Zr_{65}$ (right)

Measurement of small and/or absorbing sample is one of the most promising field of the application. In Fig. 4 is shown the S(Q) measured for an amorphous alloy of $Ni_{60}{}^{N}B_{40}$[4] (natural boron compound, 0.4 gr in weight) to demonstrate the higher performance of the HIT for this application[4].

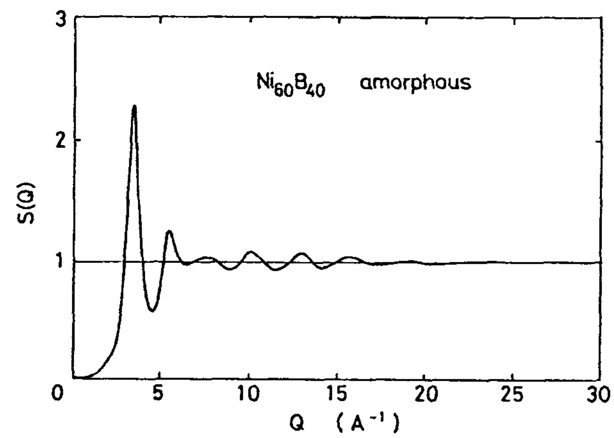

Fig. 4 S(Q) of amorphous $Ni_{60}B_{40}$ (natural boron compound, 0.4 grams)

3.2 LAM

The LAM is the inverted geometry quasielastic spectrometer with the conventional energy resolution[5]. The spectral distortion is very small due to the inverted geometry and the nearly flat cold source spectra. The signal-to-background ratio is extremely good because of the pulsed source. This spectrometer is of value in the performance of peak profile analysis in quasielastic studies. Fig. 5 shows the raw data of the quasielastic spectra recently obtained from the deuterium substituted methanols and their

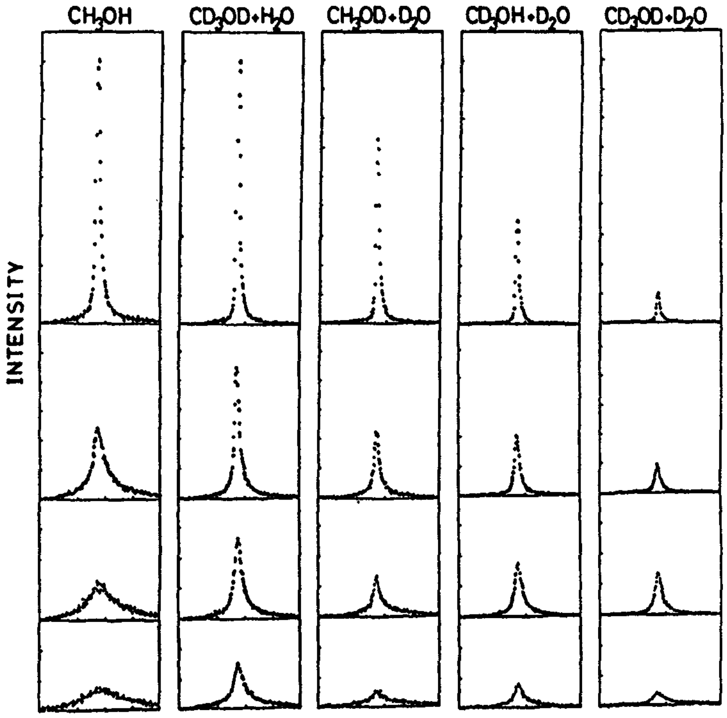

Fig. 5 Scattered spectra from the deutrium substituted methanols and their aqueous solutions measured by the LAM. From top figure to bottom one the scattering angle varies from 25° to 115°.

aqueous solutions at ambient temperature[6]. These data are useful for the investigation of the dynamical structure of the water, methanol, and their solutions. Investigations concerning the polymers and polymer solutions, some magnetic materials and hydrogen diffusion in amorphous metal also continuing.

3.3 MAX

MAX is the multi-analyzer crystal spectrometer equipped with fifteen separate analyzer crystals[7]. The spectrometer was constructed to test, first of all, the feasibility of the TOF machine for studying the collective excitations. Fig 6 is the results of scattering from a single crystal of Fe(Si) measured along [111] around the (110) reciprocal lattice point[8]. Fig. 6(a) is the TOF spectra, while Fig. 6(b) shows magnon and phonon dispersions along [110] simultaneously obtained. The broken lines are the dispersions previously obtained by triple axis spectrometers. We found the magnon scattering could be well detected up to 70 meV. The results are quite encouraging and the spectrometer would be used for studying the collective excitlation in non-equilibrium system.

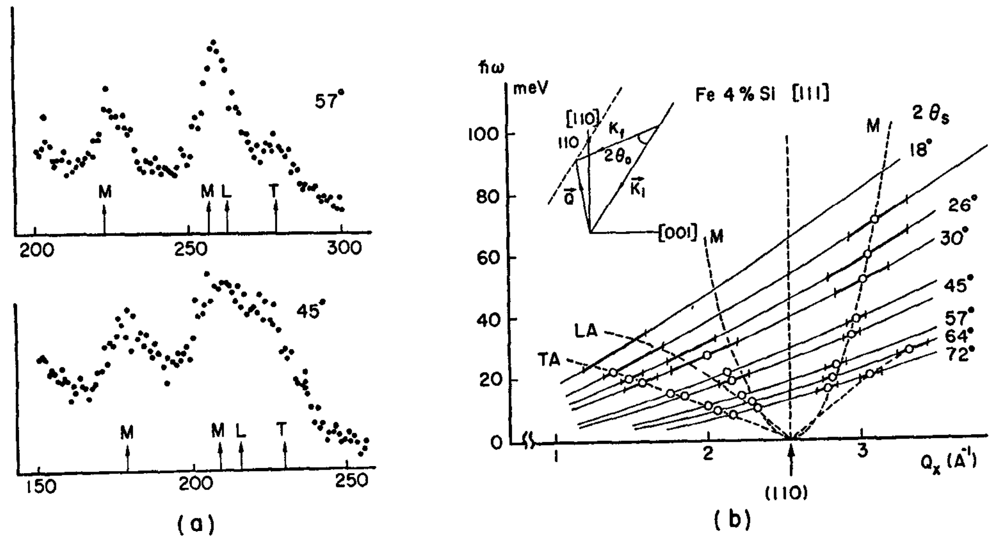

Fig. 6 Coherent scattering from a single crystal of Fe(Si) measured by MAX along [111] around the (110); (a) typical TOF spectra of scattered neutrons at selected scattering angles, (b) magnon and phonon dispersions.

3.4 SAN

SAN is the small angle scattering spectrometer equipped with a movable two dimensional PSD inside a vacuum chamber[9]. A characteristic of the spectrometer is its feasibility to measure simultaneously a wide range of momentum transfers from 3×10^{-3} to 4 A^{-1}. Fig. 7 is an example to demonstrate this fact, where the scattering from a Al-10%Zn-0.1%Mg is shown[10]. The low Q data is the one dimensional display of the two dimensional PSD data, while the insert to the figure is the result from a fixed counter with a scattering angle of 150°. This characteristic is particularly useful for studying non-equilibrium phenomena as spinodal decomposition or magnetic response in the spin glass systems, and the routine studies have been carried out on this field.

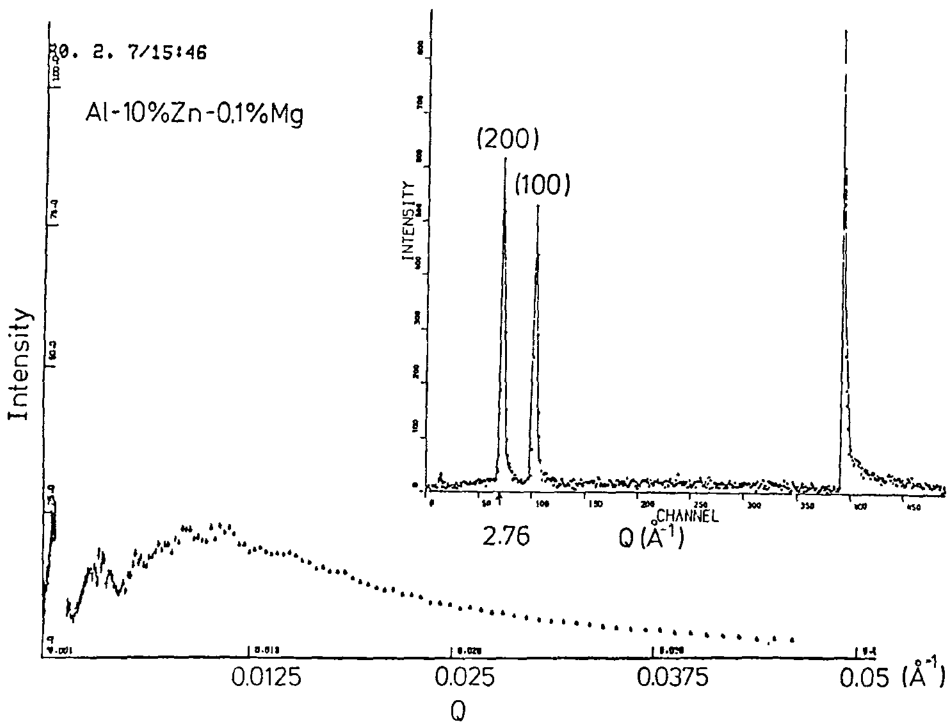

Fig. 7 Small angle scattering from a Al-10%Zn-0.1%Mg measured by SAN: insert to the figure is the results measured by a fixed conventional counter at 2Θ = 150°.

Another characteristic is its convenience for studying the single crystals. In Fig. 8 is shown the Bragg scattering from a single crystal of MnSi at 10 K with a long period of 180 A[10]. The figures correspond to the on-line display of 2D-data of satellites with Q = 0.035 in two different wave length ranges. The spectrometer could determine the wave length dependence of the satellites peaks as well as the size of the satellites from which we found a new fact that the helical structure has a shorter dimension of about 1,000 A in the screw axis compared with that in the perpendicular direction which is about 4,000 A. The extinction free intensity could also be determined.

Small angle scattering from polystyrene latex, collagen in hen and purple membrane have also been measured.

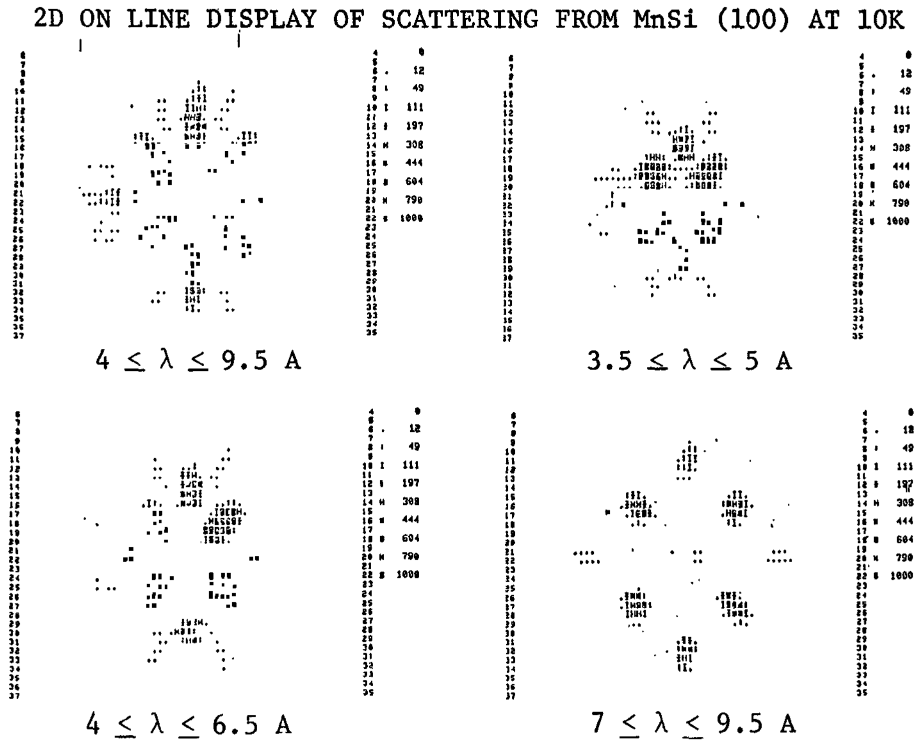

Fig. 8 Bragg scattering from a single crystal of MnSi at 10 K measured by 2D PSD of SAN in different wave length ranges.

3.5 TOP

TOP is the polarized cold neutron spectrometer utilizing total reflection from a Soller slit of Fe-Co[11]. The polarizer itself as well as the scattering apparatus was largely improved since last ICANS. A recent measurement on the polarizability using the (111) reflection of a Heusler crystal as a polarization analyzer suggests that the polarizability is more than 95 % over an entire range of wave length from 4 A to 12 A. (See Fig. 9.)

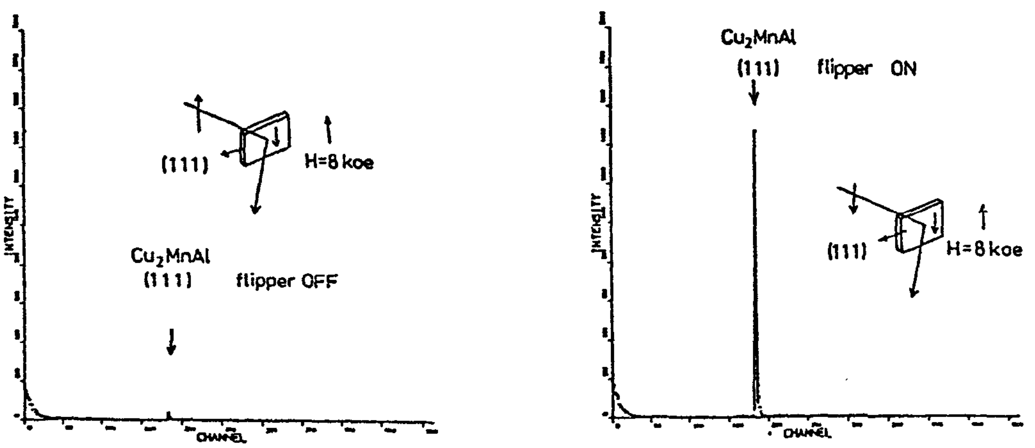

Fig. 9 Polarization dependent 111 *reflections from the Heusler analyzer for the polarizability test.*

The current studies with TOP are primarily concentrated on the small angle scattering from magnetic disordered alloys as well as magnetic bilayers. In Fig. 10 is demonstrated a typical polarization dependent TOF diffraction patterns obtained from bilayer films of Fe-Pd and Fe-Sb[12].

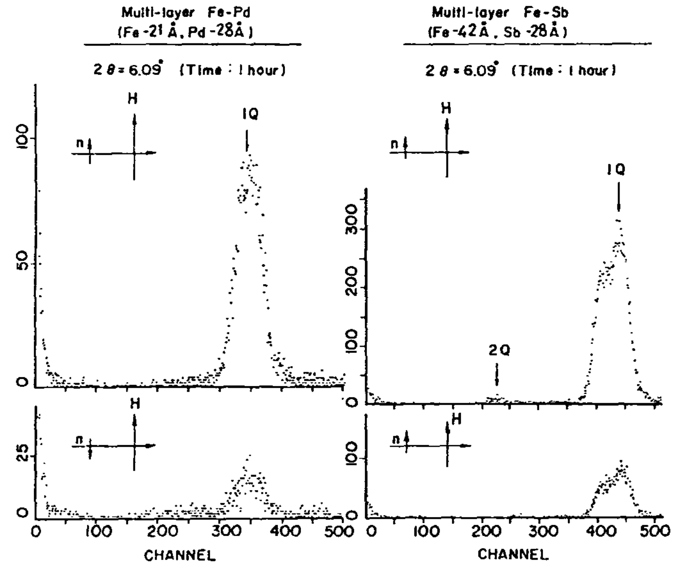

Fig. 10 Polarization dependent TOF diffraction patterns obtained from films of Fe-Pd and Fe-Sb.

3.6 PEN

PEN is the polarized epithermal neutron spectrometer designed for studying the high energy magnetic excitations. The polarization of epithermal neutrons will be achieved by using a dynamically polarized proton filter[13]. The spectrometer will be completed at the end of 1982, and the study of the polarizing process of the proton spins by means of the dynamical polarization will be started from April of 1982.

3.7 FOX

FOX is the single crystal diffractometer equipped with a conventional four circle goniometer which has been installed at H1 beam hole by the user's group at National Institute for Research in Inorganic Materials. The instrument has a conventional detector at present time which will be replaced by a position sensitive area detector in near future.

3.8 RAC

RAC is a epithermal neutron spectrometer using a resonance detector which is planned to construct in coming two fiscal years. A test set-up for various resonance detectors has been installed at H7 beam hole, and developing studies of the detector has started. Another epithermal neutron spectrometer using a crystal analyzer has been constructed and installed at the same beam hole (H7). The instrument is essentially the same to the crystal analyzer spectrometer at Tohoku linac[14] but with higher performance.

§4 Future Program

Based on the encouraging results obtained by both of the neutron and the meson groups, improvement of the present machine as well as the future plans have started to be discussed.

4.1 KENS-I'

KENS-I' is a project to increase the effective neutron beam intensity on the sample about one order of magnitude by means of the improvement of the present accelerator as well as the target station as early as possible. Following factors are under consideration and studies for that have already started.

4.1.1. Accelerator

The conversion of the injection scheme in the booster synchrotron to the charge exchange injection with H^- ions is one of the shortest way to increase the proton beam current from the booster. The developments of the ion source, the pulsed magnet for the orbit dump and its power supply, the preparation of the stripper, etc. are now in progress together with the project of the acceleration of the polarized proton beam. H^- ion beam will be delivered to the booster synchrotron in 1983. The beam intensity will be increased by a factor of two by this conversion.

4.1.2. Target-moderator-reflector Assembly

The efficiency of the present KENS target-moderator-reflector assembly is already in higher level if we compare it with those at other laboratories[15). The reason will be as follows:

(i) The target is not diluted by the cooling channels due to the lower power dissipation.

(ii) The distances between target and moderator were minimized.

(iii) The target of the rectangular shape in the cross section was adopted which can increase the lackage of fast neutrons towards the moderators.

(iv) Solid methane moderator was adopted as the cold neutron source which can provide higher cold neutrons intensity than liquid hydrogen moderator.

In addition to the above reasons, the shorter distance between moderator and sample due to the thinner bulk shield of KENS can provide higher beam intensity at the sample position for many applications.

We believe, however, that there exist still much room for improving the efficiency of the target-moderator-reflector assembly by the further optimization. A program for it has started which includes the items below.

(i) Optimization of the moderator size under the actual boundary conditions of the existing compornents: especially the possibility for converting the present solid methane moderator to a larger one (in lateral dimensions).

(ii) Optimal coupling (or decoupling) between target and moderator: especially the possibility for converting the present KENS solid methane moderator to a coupled one at an acceptable sacrifice of the pulse characteristics, and the possibility to reduce the thickness of the present B_4C decoupler for the polyethylene moderator which might be too thick for most applications.

(iii) Optimal shape of the moderator: various grooved moderator for both embient temperature and cold moderators.

(iv) Optimal reflector-filter: performance of the solid methane moderator with a reflector-filter of para-hydrogen or cooled beryllium.

Most opeimization studies listed above will be performed using Hokkaido linac and its cold neutron source. Some preliminary measurements were already performed at Hokkaido on a coupled and a decoupled solid methane moderators. It turned out that the beam intensity of cold neutrons from the coupled moderator was higher by about 35 percent than that from the decoupled one, while the increase in pulse width for the former was less than 15 percent[16]. This fact suggests that a higher gain factor for a couple solid methane moderator will be expected for KENS, because the reflector saving in KENS is much larger than that in Hokkaido.

We are expecting a total gain factor of, at least, 1.5 by the further optimization of the assembly.

4.1.3 Uranium Target

The convension of the present tungsten target to a depleted uranium is planned in order to increase the neutron yield by a factor of two. We believe that the rectangular shape of the present target should be conserved to keep the higher coupling efficiency between target and moderator. A Zircaloy-2 clad U alloy target is considered, which will be produced and supplied by Argonne National Laboratory. Some developments of the cladding for the rectangular shape target will, of course, be necessary in some extent. Uranium target and its cooling system should be designed for the proton beam current of several μA which might, in best case, be expected for the improved machine. We are planning to use a uranium target, at latest, in early 1984. Design studies for the heat transfer and for the thermal stress have started.

The present bulk shield of KENS-I will be adequate for KENS-I' because the measured radiation level is one third or one fourth of the regulation, and because the high energy neutron flux is proportional to the proton beam intensity, not depending upon the target material.

4.1.4. Guide Tube

The time averaged integral cold neutron flux obtained at the guide tube exit is about 1 x 10^5 n/cm^2•sec which is almost a half of the expected value. The reason is due to the fact that the transmittance of the guide tube was only 50 per cent[17]. Improvement of the transmittance has started which belongs to KENS-I project rather than KENS-I', but we can expect, in best case, another gain factor of 1.6 in cold neutron intensity from the guide tube.

4.2 KENS-II

KENS-II is a big project to construct a new accelerator and a neutron scattering facility so as to make the neutron scattering research with a neutron beam intensity 100 times higher than KENS-I. Although we have made no decision on the choise between the pulsed and quasi-continuous neutron sources, the KENS group people incline for a moment on a side of the pulsed neutron source and hope to make an optimized design to achieve the desired neutron flux on the sample position with the minimum power supply. Since a big project of TRISTAN at KEK has been approved, it will be an improtant point of discussion that our new acclerator will be built as a part of the project (as an injector to the new machine) or not. Anyway, the new accelerator will be shared, at least, with the meson group. The design studies on a high intensity accelerator for the pulsed neutron source and pulsed meson source have got under way.

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