

14-5 Neutrons Clarify the Full Picture of Atomic Motions

— Novel Method for High Efficiency Inelastic Neutron Scattering Measurement Demonstrated in J-PARC —

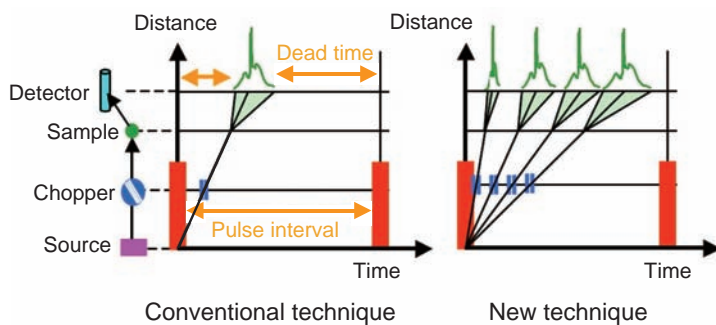


Fig.14-10 Principle of inelastic neutron scattering measurement at pulsed neutron source

The new experimental technique utilizing multiple incident energies can markedly reduce the measurement dead time, leading to enhancement of measurement efficiency.

Atoms in a material vibrate while cooperatively coupled with neighboring atoms. This atomic motion in a material is closely related to unique material functions such as high- T_c superconductivity. Inelastic Neutron Scattering (INS) experiments can visualize atomic dynamical information for a material. Conventional INS experiments that use single incident energy (E_i) have the disadvantage of low measurement efficiency and so require a long measurement time and a large sample amount.

To overcome this difficulty, we proposed the idea that the simultaneous utilization of multiple E_i 's can enhance the INS measurement efficiency (Fig.14-10). We refer to this experimental technique as multi- E_i measurement. The 4D Space Access Neutron Spectrometer (4SEASONS) has been designed to implement multi- E_i measurement and was constructed at the Materials and Life Science Experimental Facility in J-PARC. The INS measurement efficiency will improve in proportion to the number of E_i 's. A higher chopper frequency enables higher resolution measurement and an increase in the number of available E_i 's, but it also causes some loss of intensity. Thus, we have to examine the best experimental condition in advance. The dynamical information for CuGeO_3 single crystals observed by

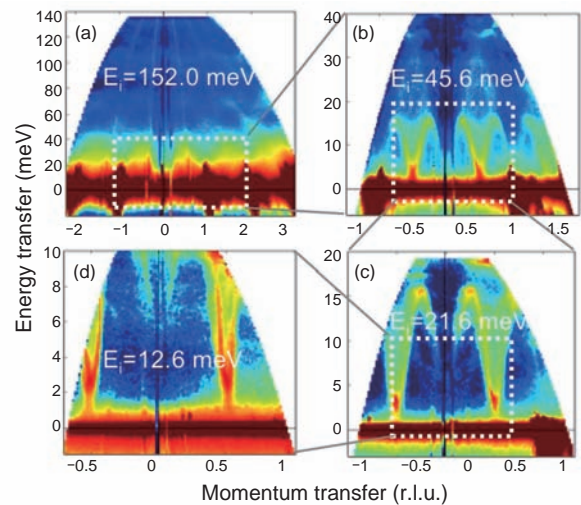


Fig.14-11 Inelastic neutron scattering spectra obtained by the new experimental technique

Four kinds of twodimensional maps that visualize the dynamical information for CuGeO_3 are obtained simultaneously. These data have a zoomin/out relation with each other.

4SEASONS is given in Fig.14-11. Four different two-dimensional maps of INS spectra are simultaneously obtained by the multi- E_i measurement, where it is possible to zoom in on the data at smaller E_i 's in the maps with higher resolution. For example, the resolution of Fig.14-11(d) is 40 times higher than that of Fig.14-11(a). Thus, we have succeeded in obtaining a full picture of dynamical information, from overall features over a wide range to precise features in a fine range, as with an Internet map service that can freely zoom in and out in satellite photos all over the world.

The new experimental technique we have demonstrated has great potential for markedly enhancing the opportunity to discover new phenomena. When the neutron source at J-PARC is operated at the rated maximum power of 1 MW, the measurement efficiency will improve more than ten times from the current stage, and then multi- E_i measurement is expected to explore a new frontier of condensed matter science.

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Reference

Nakamura, M. et al., First Demonstration of Novel Method for Inelastic Neutron Scattering Measurement Utilizing Multiple Incident Energies, Journal of the Physical Society of Japan, vol.78, no.9, 2009, p.093002-1–093002-4.