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Summary for Chapter 3 (Neutron Reflectometry), Chapter 4 (Optics of Ultracold Neutrons) and Chapter 7 (Very Low Energy Neutron Sources)

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Summary for Chapter 3 (Neutron reflectometry)

This session was devoted to recent theoretical and experimental work in neutron reflectometry. It is my impression that, while new methods of reflectivity data inversion (allowing to obtain the scattering length density depth profile in real space) are being advanced, experimentalists tend to resort to the old but very flexible trial and error method of model fitting using the matrix or recursion method. A further possible new avenue in reflectometry (not discussed in this Conference) may be the measurement of quasi-elastic components of reflection, e.g. in surface critical scattering. The high resolution needed for such studies is achievable using ultracold neutrons or cold neutron spin-echo spectrometry.

Recent theoretical developments in analyzing and inverting specular reflectivity were presented by N. Berk and C. Majkrzak. These methods involve the use of marker layers and allow exact solution of the phase problem if the potential satisfies certain requirements.

Experimental work in polarized neutron reflectometry was discussed by A. Schreyer. In this work the exchange coupling in Fe/Cr and Co/Cu(111) superlattices was studied. Furthermore, the measurement of spin-flip and non-spin-flip-reflectivities allows to determine the three-dimensional magnetic structures in these systems (canting angles).

Another broad domain of application of neutron reflectometry is the study of polymers at and near surfaces. Y. Matsushita presented experimental data on mesoscopic multiphase structures and interfaces of block and graft copolymers in bulk. These systems are of enormous economic importance, and the wide variety of ordered structures that is relevant for their function is clearly revealed by neutron reflection.

Summary for Chapter 4 (Optics of Ultracold Neutrons)

The session on ultracold neutrons covered fundamental aspects of UCN physics as well as new techniques and projects. In addition to the well-known experiments measuring the decay properties of the neutron and searching for its electric dipole moment, the use of UCN in neutron optical systems and in high-resolution spectroscopy has developed into an active field of fundamental physics and research of complex systems.

In this session, M. Utsuro *et al.* presented plans for polarized neutron decay studies using a large UCN trap filled by the supermirror turbine at Kyoto University Research Reactor Institute. Tests using a small bottle have already been performed and large solid-state detectors for decay particle observation have been developed.

N. Inoue *et al.* reported studies of UCN confinement in a multiple cusp magnetic field which is generated by permanent magnets and can hold neutrons with energies up to 20 neV.

S. Masalovich and A. Frank proposed a novel technique of neutron microscopy where the neutron spin precession is used as a phase marker.

A silicon UCN detector with a converter of Li-6 fluoride or hydroxide was tested at the KURRI source by T. Kitagaki *et al.* This type of detector can be operated in liquid helium.

Finally, the contribution by S.S. Malik and A. Steyerl dealt with the so-called "anomalies" indicated by storage and diffraction experiments with UCN: the puzzle of unexplained losses in UCN storage; an indication of an unexpected spectral change of the UCN gas during storage; and data suggesting a surprising line broadening in UCN diffraction from a grating.

Summary for Chapter 7 (Very Low Energy Neutron Sources)

At present there is a severe "drought" of ultracold neutrons. Only two sources of very low energy neutrons are operational worldwide: the turbine source at the High-Flux Reactor of the Institut Laue-Langevin in Grenoble, France, and the supermirror-turbine source at the Kyoto University Research Reactor Institute in Kumatori, Japan. The session on very low energy neutron sources presented a comprehensive overview over the existing facilities as well as a discussion of plans for the future.

In the first contribution of this session, P. Geltenbort reviewed UCN sources with emphasis on the source at the ILL reactor. The ILL source produces a UCN density of about 50 per cm^3 (for a limiting velocity of 6.2 m/s, as for stainless steel), and a current density of 10^4 per cm^2 and s over a beam cross section of about 100 cm^2. The supermirror turbine source at Kyoto University Research Reactor Institute generates about 10^{-3} of the ILL value. The source at Gatchina which had produced about one third of the ILL intensity is not operational at the present time.

In the second contribution, Pokotilovski *et al.* proposed a new method of direct UCN extraction from a TRIGA reactor or other low-repetition pulsed neutron source. The high density of UCN available in a cold source during the pulse of the primary source is conducted by a guide tube to a storage vessel. An alternative idea involving a movable bottle which is filled during the pulse, is currently being tested at Arzamas by A. Strelkov.

A. Serebrov *et al.* presented theoretical and experimental gain factors for UCN production using a solid deuterium

converter. A very high gain factor of 1500 was measured in low-flux conditions at the Gatchina reactor. A solid deuterium converter is being considered for the planned upgrading of the Los Alamos Spallation Neutron Source.

The plans of the Los Alamos group were then discussed in detail by S. Seestrom *et al.* The short-range plans of this group include implementation of a mica crystal turbine at a boosted short-pulse source. This facility is expected to yield a UCN density of about 10 per cm^3. The scientific applications will be centered around problems in Fundamental Physics.

The supermirror turbine source at the Kyoto University Research Reactor (KUR) was presented by Y. Kawabata and M. Utsuro. In this installation, very cold neutrons from the liquid deuterium Cold Source at KUR are decelerated to the UCN region by segmented supermirror blades.

In conclusion of these summaries, it is a pleasure to acknowledge the excellent organization of this Conference by Professor Utsuro and the entire KURRI team. The great hospitality and friendly atmosphere that we have enjoyed here in Kumatori will be unforgettable. Thank you all.