

Contents

Preface

M. UTSURO

Symposium Photo

Committee

Supports and Acknowledgments

Message to the Symposium "Neutron Optics in Kumatori '96"

C. G. SHULL

Welcome Address

Y. MAEDA

Message from Japanese Ministry

K. ICHIKAWA

Chapter 1. Fundamental Physics of Neutron Optics

Fundamentals of Neutron Optics

V. F. SEARS	1
Multiple Wave Scattering Formalism and the Rigorous Evaluation of Optical Potential for Three-dimensional Periodic Media	
V. K. IGNATOVICH	7
Dynamic Neutron Optics	
A. I. FRANK and V. G. NOSOV	13
Quantum Mechanical Observation	
M. NAMIKI	19
Synthesized Larmor Precessions and Particle Density Waves	
F. MEZEI	25
Proposed Fundamental Investigations Using Neutron Interference Filters and Gravity Spectrometry	
I. V. BONDARENKO, A. I. FRANK, S. N. BALASHOV, S. V. MASALOVICH and V. G. NOSOV ...	29
Effect of Fluctuation and Dissipation on Neutron Scattering	
H. NAKAZATO, K. MACHIDA, M. NAMIKI and S. PASCAZIO	33
Off-Specular Neutron Reflection from Magnetic Media with Nondiagonal Reflectivity Matrices	
D. K. KORNEEV, V. I. BODNARCHUK and V. K. IGNATOVICH	37
Estimation of Tunneling Time Based on the Quantum Diffusion Process Approach and Neutron Scattering	
I. OHBA, K. IMAFUKU and Y. YAMANAKA	41

Chapter 2. Neutron Interferometry

Quantum Optics View of Neutron Interferometry

H. RAUCH	45
Quantum Phase Shifts Induced by Gravity and Rotation	
S. A. WERNER	51
Polarized Neutron Interferometry	
G. BADUREK	60
Neutron Spin Quantum Precession Using Multilayer Spin Splitters and a Phase-Spin Echo Interferometer	
T. EBISAWA, S. TASAKI, T. KAWAI, M. HINO, T. AKIYOSHI, N. ACHIWA, Y. OTAKE and H. FUNAHASHI	66
Quantum Phase Shift of de Broglie Waves by Spatial Confinement	
S. GRIFFIN, A. CIMMINO, A. KLEIN, G. OPAT, B. E. ALLMAN and S. A. WERNER	71
Neutron Interferometric Separation of Geometric and Dynamical Phases	
A. G. WAGH, V. C. RAKHECHA, J. SUMMHAMMER, G. BADUREK, H. WEINFURTHER, B. E. ALLMAN, H. KAISER, K. HAMACHER, D. L. JACOBSON and S. A. WERNER	73

Neutron Polarization Control by Interferometer	
S. NAKATANI, T. TAKAHASHI, H. TOMIMITSU and S. KIKUTA	77
New Type of Neutron Polarizer for Neutron Interferometer	
A. IOFFE, P. FISCHER, T. KRIST and F. MEZEI	80
Study of Electromagnetic Structure of the Neutron by Neutron Interferometry Method	
A. IOFFE, M. VRANA and V. ZABIYAKIN	82
Two Wavelength Difference Measurement of Gravitationally-Induced Quantum Interference Phases	
K. LITTRRELL, B. E. ALLMAN, K. HOAG and S. A. WERNER	86
Geometric Phase in a Split-Beam Experiment Measured with Coupled Neutron Interference Loops	
Y. HASEGAWA, M. ZAWISKY, H. RAUCH and A. IOFFE	90
Neutron Interferometric Measurement of Neutron Pair Correlations for Multiple Detectors	
D. L. JACOBSON, B. E. ALLMAN, M. ZAWISKY, S. A. WERNER and H. RAUCH	94
Neutron Interferometry in Non- Inertial Reference Frames	
K. LITTRRELL, S. A. WERNER and B. E. ALLMAN	98
A Neutron Interferometric Test for Quaternion Quantum Mechanics	
B. E. ALLMAN, K. LITTRRELL, A. KLEIN, A. CIMMINO, G. OPAT and S. A. WERNER	102
Chapter 3. Neutron Reflectometry	
Inverting Specular Neutron Reflectivity from Symmetric, Compactly-Supported Potentials	
N. F. BERK and C. F. MAJKRZAK	107
Polarized Neutron Reflectometry on Exchange Coupled Superlattices	
A. SCHREYER	113
Mesoscopic Multiphase Structures and the Interfaces of Block & Graft Copolymers in Bulk	
Y. MATSUSHITA	119
Surface and Interface Roughness of a Binary-Liquid System	
U. S. JENG, L. ESIBOV, M. L. CROW and A. STEYERL.....	124
Studies on Microphase-Separated Structures of Block Copolymers by Neutron Reflectivity Measurement	
N. TORIKAI, I. NODA, Y. MATSUSHITA, A. KARIM, S. K. SATIJA, C. C. HAN and T. EBISAWA	128
A Neutron Reflectometer Installed at the Cold Neutron Triple-Axis Spectrometer (LTAS, C2-1) in JRR-3M	
K. SOYAMA, N. METOKI, N. MINAKAWA, Y. MORII, N. TORIKAI and Y. MATSUSHITA....	133
Investigation of Surface Metal Oxide Formed in 10^{-4} Torr Oxygen by Neutron Reflectometry	
S. TASAKI, T. EBISAWA and T. KAWAI	136
Unique Analysis of Neutron Specular Reflection Measurements	
H. LEEB, R. LIPPERHEIDE and G. REISS	138
Chapter 4. Optics of Ultracold Neutrons	
Fundamental Physics with Ultracold Neutrons	
A. STEYERL and S. MALIK.....	143
Ultracold Neutron Bottle for Neutron Decay Studies	
M. UTSURO, Y. KAWABATA, A. YAMAGUCHI, T. MIYACHI, S. TASAKI and K. OKUMURA... .	149
Confinement of UCN in a Multiple Cusp Magnetic Field	
N. INOUE, H. NIHEI, N. AKIYAMA and K. KINOSITA	155
Neutron Microscope with Phase Contrast	
S. MASALOVICH and A. FRANK.....	159
A New Type of Solid-State Detector for Ultra-Cold Neutrons	
T. KITAGAKI, O. KONNO, M. HIGUCHI, M. SATO, T. KAWASHIMA, E. SATO, M. UTSURO and Y. KAWABATA	163
Chapter 5. Optics of Polarized Neutrons	
Test of Parity and Time Reversal Invariance with Low Energy Polarized Neutrons	
A. MASAIKE	169
Neutron Interferometry Method of Study of Parity Violation in Cold Neutron Transmission	
A. IOFFE	174
Search for Neutron EDM Using Crystal Techniques	
C. M. E. ZEYEN, Y. OTAKE, T. TABARU and B. TOPERVERG	177

Neutron Spin Echo Optics

N. ACHIWA, M. HINO, S. TASAKI, T. Ebisawa, T. AKIYOSHI and T. KAWAI	183
A Neutron Spin Echo Spectrometer with an Assembly of Position Sensitive Detectors T. TAKEDA, H. SETO, S. KOMURA, S. K. GHOSH, M. NAGAO, J. MATSUBA, H. KOBAYASHI, T. EBISAWA, S. TASAKI, C. M. E. ZEYEN, Y. ITO, S. TAKAHASHI and H. YOSHIZAWA.....	189
Multichannel Neutron Polarizers Produced in PNPI A. SCHEBETOV, N. PLESHANOV, V. SYROMYATNIKOV, V. PUSENKOV, B. PESKOV, G. SHMEL'EV, Z. SOROKO and V. UL'YANOV.....	195
Polarizing Beam-Splitter Device at a Pulsed Neutron Source S. ITOH and M. TAKEDA	199
Traversal Time through Magnetic Thin Film Using Larmor Precession M. HINO, N. ACHIWA, S. TASAKI, T. EBISAWA, T. AKIYOSHI and T. KAWAI	203
Experiment on Transportation of Very Cold Neutron Flux by a Multipole Magnetic Field N. AKIYAMA, H. NIHEI, N. INOUE, M. UTSURO and Y. KAWABATA	207
A New Neutron Polarizer for Neutron Interferometry Experiments W. T. LEE, O. MOTRUNICH, B. E. ALLMAN and S. A. WERNER	210

Chapter 6. New Techniques in Neutron Optics

Neutron Resonance Spin Echo

W. BESENBOCK, P. HANK, M. KÖPPE, R. GÄHLER, T. KELLER and R. GOLUB	215
Neutron Depolarization Measurement by Using Pulsed Polarized Neutrons Y. ENDOH	221
Magnetically Remanent Single Layer Neutron Polarizers T. KRIST, R. GÖTTEL, P. SCHUBERT-BISCHOFF and F. MEZEI	226
A Multilayer Cold Neutron Pulser Working under an External Magnetic Field Less than 50 Gauss T. KAWAI, T. EBISAWA, S. TASAKI, T. AKIYOSHI, M. HINO, N. ACHIWA, Y. OTAKE and H. FUNAHASHI	230

Polarizing Neutron Guide of a V-Shape-Mirror with Pulsed Cold Neutrons

M. TAKEDA, K. KURAHASHI, Y. ENDOH and S. ITOH	234
On the Neutron Reflectivity of Different Nickel Mirrors R. M. A. MAAYOUF	238

Bent Crystal Analyzer in Fully Asymmetric Diffraction Geometry for Neutron Scattering Instrumentation

P. LUKÁŠ, Z. KOUŘIL, P. MIKULA, J. ŠAROUN, P. STRUNZ, M. VRÁNA and V. WAGNER... The Osiris Polarization Analysis Spectrometer and Diffractometer D. MARTÍN, S. CAMPBELL and C. J. CARLILE	241
Upgrade of Neutron Guides with Use of Supermirrors K. AL USTA, K. N'GUY, A. MENELLE and F. SAMUEL	245
NDT-Observation of Superalloy Single Crystals Grown into the Gas-Turbine Blade H. TOMIMITSU, K. IIJIMA, K. AIZAWA and A. YOSHINARI	249
252	

Chapter 7. Very Low Energy Neutron Sources

Production and Storage of Ultra Cold Neutrons at Pulse Neutron Sources with Low Repetition Rates

Y. N. POKOLOVSKI and A. Yu. MUZYCHKA	255
Experimental Study of a Solid-Deuterium Source of Ultracold Neutrons A. P. SEREBROV, V. A. MITYUKHLYAEV, A. A. ZAKHAROV, A. G. KHARITONOV, V. V. NESVIZHEVSKII, M. S. LASAKOV, R. R. TAL'DAEV, A. V. ALDUSHCHENKOV, V. E. VARLAMOV, A. V. VASIL'EV, G. L. GREENE and T. J. BOWLES.....	259
Ultra Cold Neutrons at a Spallation Source T. J. BOWLES, R. HILL, G. L. GREENE, S. J. SEESTROM and A. P. SEREBROV	264
Design of High Efficiency Supermirror Neutron Turbine Y. KAWABATA and M. UTSURO	267

Chapter 8. Other Recent Developments

8A. Neutron Optics

New Aspects of Dynamical Diffraction Phenomena of Neutrons T. TAKAHASHI	271
--	-----

Gravity and Inertia in Neutron Crystal Optics and VCN Interferometry	277
K. RAUM, M. WEBER, R. GÄHLER and A. ZEILINGER	277
Spin Interference of Neutrons Tunneling through Magnetic Thin Films	
M. HINO, N. ACHIWA, S. TASAKI, T. EBISAWA, T. AKIYOSHI and T. KAWAI	281
Quantum Zeno Effect	
S. PASCAZIO, H. NAKAZATO and M. NAMIKI	285
Fabrication and Characterization of Nickel Titanium Multilayer Neutron Supermirrors	
S. BASU, G. S. LODHA, K. YAMASHITA, K. HAGA, K. MISAKI and K. AKIYAMA.....	289
Neutron Spin Tomography: A Tool to Visualize Magnetic Domains in Bulk Materials	
M. HOCHHOLD, H. LEEB and G. BADUREK	292
Fabrication and Performance of a Large Wavelength Band Multilayer Monochromator	
P. HØGHØJ, I. S. ANDERSON, T. EBISAWA and T. TAKEDA.....	296
8B. Neutron Sources	
The Research Reactor Project FRM-II and its Neutron Guide System	
E. STEICHELE	299
Multipurpose Research Reactor JRR-3M and its Neutron Beam Experimental Facilities	
N. ONISHI, M. MATSUBAYASHI and K. SOYAMA	303
Characteristics and Applications of a Polycapillary Neutron Focusing Lens	
D. F. R. MILDNER, H. H. CHEN-MAYER and R. G. DOWNING.....	308
The Focusing Mirror at the ILL Spin-Echo Spectrometer IN15: Experimental Results	
C. HAYES, C. LARTIGUE, A. KOLLMAR, J. R. D. COBLEY, B. ALEFELD, F. MEZEI, D. RICHTER and T. SPRINGER.....	312
Neutron Beam Control Using Polycapillary Optics	
Q. F. XIAO, V. A. SHAROV, R. G. DOWNING, H. H. CHEN-MAYER and D. F. R. MILDNER	316
Monolithic Polycapillary Neutron Focusing Lenses: Experimental Characterizations	
H. H. CHEN-MAYER, D. F. R. MILDNER, V. A. SHAROV, J. B. ULLRICH, I. Yu. PONOMAREV and R. G. DOWNING	319
Neutron Guide Facility at the ET-RR-1 Reactor	
R. M. A. MAAYOUF, V. TROUNOV, V. KUDRYASHEV, A. BULKIN, I. A. ABDEL-LATIF and A. S. EL-KADY	322
Chapter 9. Summaries	
Summary of Chapter 1 (Fundamental Physics of Neutron Optics), Chapter 2 (Neutron Interferometry), and the Related Poster Sessions.	
H. RAUCH.....	325
Summary for Chapter 3 (Neutron Reflectometry), Chapter 4 (Optics of Ultracold Neutrons) and Chapter 7 (Very Low Energy Neutron Sources)	
A. STEYERL	327
Summary on Chapter 5 (Optics of Polarized Neutrons) and Chapter 6 (New Techniques in Neutron Optics)	
R. GÄHLER	329
Summary Remarks on Chapter 8 (Other Recent Developments) and the Related Poster Sessions	
V. K. IGNATOVICH.....	333
Author Index.....	339
Keyword Index.....	341
List of Participants	344

