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¹At Boulder, CO 80303

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Cover: Photograph of the southern-most lake on the NIST campus. Illustration arranged by C. Carey.

The *Journal of Research of the National Institute of Standards and Technology*, the flagship periodic publication of the national metrology institute of the United States, features advances in metrology and related fields of physical science, engineering, applied mathematics, statistics, biotechnology, and information technology that reflect the scientific and technical programs of the Institute. The *Journal* publishes papers on instrumentation for making accurate measurements, mathematical models of physical phenomena, including computational models, critical data, calibration techniques, well-characterized reference materials, and quality assurance programs that report the results of current NIST work in these areas. Occasionally, a Special Issue of the *Journal* is devoted to papers on a single topic. Also appearing on occasion are review articles and reports on conferences and workshops sponsored in whole or in part by NIST.

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*Papers and Posters Presented at the April 2004 International
Conference on Precision Measurements with Slow Neutrons at
the National Institute of Standards and Technology*

Preface

This Special Issue of the Journal of Research of the National Institute of Standards and Technology (Parts 1 and 2) contains papers from the International Conference on Precision Measurements with Slow Neutrons held at the National Institute of Standards and Technology in Gaithersburg, MD, April 5–7, 2004. They highlight new results and developments in such topics as neutron electric dipole moment searches, neutron optics and interferometry, Standard Model tests using neutron beta decay, neutron facilities, neutron polarimetry, and nucleon-nucleon interactions.

The meeting was comprised of 3 full days of oral sessions and poster presentations. Approximately 125 people from 10 countries participated in the meeting, which solicited over 120 abstracts. Their numerous contributions can be seen in the following Program listing and in the papers included in this Special Issue. All of the papers that were submitted were found to be appropriate for these conference proceedings by the special issue editors, but we note that not all were given expert review.

A full session on neutron facilities around the world highlighted the increasing number of new sources that are under construction. These facilities demonstrate the growth in the field of fundamental neutron physics and present additional opportunities for experiments requiring large densities of ultracold neutrons, exploiting higher fluences of pulsed cold neutrons, or training future generations of neutron scientists. The general consensus among the participants was that although there has been substantial progress, new challenges and opportunities in fundamental neutron physics continue to present themselves.

Finally, we acknowledge the generous financial support of the NIST Physics Laboratory and Ionizing Radiation Division, North Carolina State University, the University of Tennessee/Oak Ridge National Laboratory Joint Institute for Neutron Science, Harvard University, the Institut Laue-Langevin, LENS: the Low Energy Neutron Source, Los Alamos National Laboratory, and the Institute of Physics Publishing, Inc.

Muhammad Arif
M. Scott Dewey
Tom Gentile
Paul Huffman
Jeff Nico
Special Issue Editors

Precision Measurements With Slow Neutrons

April 5–7, 2004

Program

Sunday, April 4, 2004 — Washingtonian Hotel

7:00 pm Reception

Monday, April 5, 2004 — NIST, Green Auditorium

9:00 am *Opening Remarks* — Dr. Lisa Karam, Acting Chief, Ionizing Radiation Division
Welcome — Dr. Richard Kayser, NIST Acting Deputy Director

Electric Dipole Moment – Chair: Jeff Nico, National Institute of Standards and Technology

9:20 – 9:40 *Neutron EDM measurements with UCN at the ILL: present and future*

P. Geltenbort, Institut Laue-Langevin, Grenoble, France

9:40 – 10:00 *Search for a neutron EDM using ultracold neutrons*

R. Golub, Hahn-Meitner-Institut, Berlin

10:00 – 10:20 *Multi-chamber EDM spectrometer*

A. Serebrov, Petersburg Nuclear Physics Institute–RAS/Paul Scherrer Institut

10:20 – 10:35 *What can be learned from neutron to anti-neutron transition search*

Y. Kamyshkov, University of Tennessee

Optics I – Chair: Sam Werner, University of Missouri

11:15 – 11:35 *Coherence, quantum state engineering and phase space density enhancements*

H. Rauch, Atominstitut der Österreichischen Universitäten

11:35 – 11:55 *High-precision measurements of the n-p, n-d, and n-³He bound coherent scattering lengths*

T. C. Black, University of North Carolina at Wilmington

11:55 – 12:15 *Measurement of the coherent neutron scattering length of ³He*

W. Ketter, Universität Mainz

12:15 – 12:30 *Observation on the visibility decrease in a VCN spin resonator interferometry*

M. Utsuro, Osaka University

12:30 – 12:45 *Spatial non-cyclic geometric phase in neutron interferometry*

S. Filipp, Atominstitut der Österreichischen Universitäten

Neutron Beta Decay I – Chair: Geoffrey Greene, University of Tennessee

1:45 – 2:00 *Radiative Corrections for Neutron Decay and Search for New Physics*

V. Gudkov, University of South Carolina

2:00 – 2:15 *Standard Model Treatment of the Radiative Corrections to the Neutron β -decay*

G. Bunatian, Joint Institute for Nuclear Research, Dubna

2:15 – 2:35 *Measurement of the Neutron Lifetime Using a Proton Trap*

F. E. Wietfeldt, Tulane University

2:35 – 2:50 *A Cryogenic Radiometer for Absolute Neutron Rate Measurement*

Z. Chowdhuri, National Institute of Standards and Technology/University of Maryland

2:50 – 3:10 *Neutron lifetime experiment with gravitational trap and with lower temperature fomblin (LTF) coating*

V. Varlamov, Petersburg Nuclear Physics Institute – RAS

3:10 – 3:30 *Measuring the neutron lifetime with magnetically trapped neutrons*

S. N. Dzhosyuk, Harvard University

Neutron Facilities – Chair: Paul Huffman, North Carolina State University

4:00 – 4:15 *The Cold, Very Cold, and Ultracold Neutron Facilities PF1 (Physique Fondamentale 1) and PF2 at the Institut Laue-Langevin (ILL) in Grenoble, France*

P. Geltenbort, Institut Laue-Langevin Grenoble, France

4:15 – 4:30 *The fundamental neutron physics facilities at NIST*

J. S. Nico, National Institute of Standards and Technology

4:30 – 4:45 *A Pulsed Cold Neutron Beamline Flight Path 12 at LANSCE for Fundamental Nuclear Physics*

P.-N. Seo, Los Alamos National Laboratory

4:45 – 5:00 *The Fundamental Neutron Physics Beamline at the Spallation Neutron Source*

G. L. Greene, University of Tennessee

5:00 – 5:15 *LENS: A New Pulsed Neutron Source for Research and Education*

- 5:15 – 5:30 M. Leuschner, Indiana University Cyclotron Facility
Performance of a New Ultracold Neutron Source at Los Alamos National Lab
- 5:30 – 5:45 A. Saunders, Los Alamos National Laboratory
An Ultracold Neutron Source at PSI
- 5:45 – 6:00 M. Daum, Paul Scherrer Institut
The Mini- D_2 source for ultracold neutrons at the new research reactor FRM-II
- 6:00 – 6:15 E. Gutmiedl, Technische Universität München
The UCN source at the North Carolina State University PULSTAR reactor
- B. Wehring, North Carolina State University

Tuesday, April 6, 2004 — NIST, Green Auditorium*Neutron Beta Decay II* – Chair: John Doyle, Harvard University

- 8:30 – 8:50 V_{us} , V_{ub} , and CKM unitarity
V. Cirigliano, California Institute of Technology
- 8:50 – 9:10 *Neutron decay parameters and Instrument PERKEO*
H. Abele, University of Heidelberg Physics Institute
- 9:10 – 9:30 *Progress toward a Precision Measurement of the Neutron β -Decay Asymmetry using Ultracold Neutrons at LANSCE*
T. Ito, California Institute of Technology
- 9:30 – 9:45 *Project of neutron beta-decay A-asymmetry measurement with accuracy on the level 10^{-3}*
A. Serebrov, Petersburg Nuclear Physics Institute – RAS
- 9:45 – 10:00 *Measurement of Neutron Decay Parameters—The abBA Experiment*
J. D. Bowman, Los Alamos National Laboratory

Time Reversal Violation – Chair: Chris Gould, North Carolina State University

- 10:45 – 11:05 *The T-odd R- and D- Correlations in Beta Decay*
P. Herczeg, Los Alamos National Laboratory
- 11:05 – 11:25 *A new measurement of the D coefficient with TRINE*
C. Plonka, Technische Universität München, Germany
- 11:25 – 11:45 *Time Reversal Violation in Neutron Beta Decay: The emiT Experiment*
J. F. Wilkerson, University of Washington
- 11:45 – 12:05 *Search for Time Reversal Violation Effects: R-Correlation Measurement in Neutron Decay*
K. Bodek, JU-Kraków, Poland
- 12:05 – 12:25 *Two coils resonant Ramsey's method for the measurement of time reversal invariance violation in neutron transmission*
A. Aldushchenkov, Petersburg Nuclear Physics Institute – RAS

- 12:25 – 12:45 *On the Way to Experimental Test of the Time Reversal Invariance in the Nuclear Reactions*
T. Ino, High Energy Accelerator Research Organization

*Poster Session I**Miscellaneous Topics* – Chair: Mike Snow, Indiana University

- 2:45 – 3:05 *Constraints on new interactions from neutron scattering experiments*
Y. Pokotilovski, Joint Institute for Nuclear Research, Dubna
- 3:05 – 3:25 *Direct nn-scattering Measurement with the Pulsed Reactor YAGUAR*
G. E. Mitchell, North Carolina State University and Triangle Universities Nuclear Laboratory
- 3:25 – 3:45 *The Neutron Electric Polarizability from Neutron Total Cross Section of ^{208}Pb Measurement*
A. B. Laptev, Petersburg Nuclear Physics Institute – RAS
- 3:45 – 4:00 *Investigation of solid D_2 for UCN sources*
K. Kirch, Paul Scherrer Institut

Neutron Polarimetry/ ^3He – Chair: Gordon Jones, Hamilton College

- 4:30 – 4:50 *Precision Neutron Polarimetry and Spin Flipping*
T. E. Chupp, University of Michigan
- 4:50 – 5:05 *A Ramsey's Method with Pulsed Neutrons*
Y. Masuda, High Energy Accelerator Research Organization
- 5:05 – 5:25 *A perfectly polarised neutron beam*
T. Soldner, Institut Laue Langevin
- 5:25 – 5:40 *^3He spin filter for neutrons*
M. Batz, University of Mainz
- 5:40 – 5:55 *^3He spin filters for slow neutron physics*
T. R. Gentile, National Institute of Standards and Technology
- 7:30 pm – *Banquet* – Potowmack Landing Restaurant, Alexandria, VA – Norman Ramsey, Personal Anecdotes About Great Physicists

Wednesday, April 7, 2004 — NIST, Green Auditorium*Nucleon-Nucleon Interactions* – Chair: David Bowman, Los Alamos National Laboratory

- 8:30 – 8:50 *Parity Violation in the NN Interaction Using Low Energy Neutrons*
W. M. Snow, Indiana University/Indiana University Cyclotron Facility
- 8:50 – 9:05 *Measurement of Parity Violation in n-p Capture*
S. A. Page, University of Manitoba
- 9:05 – 9:20 *Parity-violating neutron spin rotation in a superfluid helium target*

	C. D. Bass, Indiana University		
9:20 – 9:35	<i>Parity-violating neutron spin rotation in a liquid parahydrogen target</i>	2:35 – 2:55	<i>New results on neutron quantum states in the Earth's gravitational field</i>
	D. M. Markoff, North Carolina State University		V. Nesvizhevsky, Institut Laue-Langevin
<i>Poster Session II</i>		2:55 – 3:10	<i>Quantum Contextuality in Single-Neutron Interferometer Experiments: violation of a Bell-like inequality</i>
<i>Neutron Beta Decay III</i> – Chair: Peter Geltenbort, Institut Laue-Langevin			Y. Hasegawa, Atominstytut der Österreichischen Universitäten
11:15 – 11:35	<i>Charged Current Universality and the MSSM</i>		
	A. Kurylov, California Institute of Technology		
11:35 – 11:55	<i>Determination of the Electron-antineutrino Angular Correlation Coefficient a_0 in Unpolarized Neutron Decay</i>		<i>Neutron Beta Decay IV</i> – Chair: Scott Dewey, National Institute of Standards and Technology
	J. Byrne, University of Sussex	4:00 – 4:20	<i>First ever storage of ultracold neutrons in a magnetic trap made of permanent magnets</i>
11:55 – 12:15	<i>The Neutron Decay Spectrometer aSPECT and the Unitarity of the CKM Matrix</i>		V. Ezhov, Petersburg Nuclear Physics Institute-Gatchina
	S. Baeßler, Universität Mainz	4:20 – 4:40	<i>A Neutron Lifetime Experiment Based on an "Accordion-Like" Ultracold-Neutron Storage Volume Coated with "Low Temperature Fomblin"</i>
12:15 – 12:30	<i>Proposed Measurement of the Beta-Neutrino Asymmetry in Neutron Decay</i>		B. Yerozolimsky, Harvard University
	G. L. Jones, Hamilton College	4:40 – 5:00	<i>Neutron radiative β Decay in effective field theory</i>
12:30 – 12:45	<i>On the Measurement the Neutron Lifetime Using Ultra-Cold Neutrons in a Vacuum Quadrupole Trap</i>		S. V. Gardner, University of Kentucky
	J. D. Bowman, Los Alamos National Laboratory	5:00 – 5:15	<i>Search for Radiative β-decay of the Free Neutron</i>
			J. Byrne, University of Sussex
<i>Neutron Optics II</i> – Chair: David Jacobson, National Institute of Standards and Technology		5:15 – 5:30	<i>The NIST Neutron Radiative Beta-Decay Experiment</i>
2:00 – 2:15	<i>Experimental test of Laue diffraction method of a search for neutron EDM</i>		B. M. Fisher, Tulane University
	V. V. Voronin, Petersburg Nuclear Physics Institute – RAS	5:30 pm	<i>Conference Summary</i>
2:15 – 2:35	<i>Gravitational Bound Quantum States and Limits on Large Extra Dimensions</i>		Dirk Dubbers, Universität Heidelberg
	H. Abele, University of Heidelberg Physics Institute		

Poster Session

- *Studies of Polarized ^3He at Cryogenic Temperatures*
Q. Ye, Duke University
- *Magnetometry and neutron EDM false effects*
W. Heil, Universität Mainz
- *Magnetic field stabilization for neutron EDM experiments by external field coils*
R. Henneck, Paul Scherrer Institut
- *Detector Development for the abBA Experiment*
P. -N. Seo, Los Alamos National Laboratory
- *Electromagnetic design of the aSPECT neutron decay retardation spectrometer*
F. Glück, Universität Mainz
- *A Backscatter-Suppressed Electron Detector for the Measurement of "a"*
A. Komives, DePauw University
- *Electron Detectors for the UCNA experiment at LANSCE*
J. Yuan, W. K. Kellogg Radiation Laboratory, Caltech
- *The UCNA-Si Upgrade*
J. W. Martin, California Institute of Technology

- *Novel Proton Detectors for Angular Correlations of UCN Decay*
S. Hoedl, University of Washington
- *Thin Foil UCN Monitors and Absorbers for the UCNA Project*
S. Hoedl, CENPA, University of Washington
- *GEANT4-based Study of the abBA Experiment: Detector Response and Physics Analysis*
E. Frlez, University of Virginia
- *Neutron interferometric observation of the virtual excitation and multiple scattering correction terms to the index of refraction*
K. P. Schoen, University of Missouri-Columbia
- *New phenomena in neutron diffraction and optics of a noncentrosymmetric crystal. New feasibility for the neutron EDM search*
V. V. Fedorov, Petersburg Nuclear Physics Institute
- *Constraints on non-Newtonian gravity in the nanometer range from the experiment on neutron quantum states in the Earth's gravitational field*
K. Protasov, Laboratoire de Physique Subatomique et de Cosmologie
- *Design and Simulation of a Solid Methane Moderator at the LENS Neutron Source*
Y. Shin, Indiana University/Indiana University Cyclotron Facility
- *UCN production with a single crystal of ortho-deuterium*
M. Utsuro, Osaka University
- *Solid Oxygen as an Ultracold Neutron Source*
C.-Y. Liu, Los Alamos National Laboratory
- *A New Experiment to Measure The Depolarization and Loss Probability of UCN on Diamond Like Carbon (DLC)*
A. Pichlmaier, Paul Scherrer Institut
- *Storage of fast ultracold neutrons*
L. Bondarenko, RRC Kurchatov Institute Moscow
- *UCN anomalous losses, UCN depolarization and possible connection of the both phenomena*
A. Fomin, Petersburg Nuclear Physics Institute – RAS
- *Tests of ^6Li doped glass scintillators for the detection of UCN*
G. Ban, LPC-Caen, France
- *The simulation of UCN experiments with Geant4*
P. Fierlinger, Paul Scherrer Institut
- *Estimates of the Performance of a UCN Moderator at the LENS Neutron Source*
C. -Y. Liu, Los Alamos National Laboratory
- *Development of a Long Wave Length Neutron Monochromator for Superthermal Production of Ultracold Neutrons*
L. Yang, Harvard University
- *A low noise CsI detector array for the precision measurement of parity nonconservation in $n + p \rightarrow d + \gamma$*
M. Gericke, Los Alamos National Laboratory and Indiana University
- *A New Approach to Accurate Polarimetry of Polychromatic Cold Neutron Beams with a ^3He Spin Filter*
F. E. Wietfeldt, Tulane University
- *Precision Neutron Polarimetry for Neutron Beta Decay*
S. Penttila, Los Alamos National Laboratory
- *Very slow neutron transport at pulsed heating of cold moderator*
Y. Pokotilovski, Joint Institute for Nuclear Research, Dubna
- *Design and performance of laser-pumped Cs-magnetometers for the planned UCN edm experiment at PSI*
S. Groeger, University of Fribourg
- *Measurement of Absolute Neutron Flux in Liquid ^3He*
G. L. Hansen, Indiana University
- *Silicon UCN detector with large area and with analysis of UCN polarization*
M. Lasakov, Petersburg Nuclear Physics Institute – RAS
- *Superconducting UCN polarizer for a new EDM spectrometer*
M. Lasakov, Petersburg Nuclear Physics Institute – RAS
- *Gravi-magnetic trap for UCN as a quantum oscillator*
A. Frank, Joint Institute for Nuclear Research, Dubna
- *Neutron Quantum State Tailoring*
M. Baron, Atominstitut der Österreichischen Universitäten
- *Cold neutron storage*
M. R. Jaekel, Atominstitut Wien
- *Confinement induced neutron phase*
H. Lemmel, Atominstitut M. Baron, Atominstitut der Österreichischen Universitäten
- *Simulation of Charged Particle Trajectories in the Neutron Decay Correlation Experiment abBA*
D. Desai, University of Tennessee

- *Simulation of the Performance of Fundamental Neutron Physics Beamline at the High Flux Isotope Reactor*
R. Mahurin, University of Tennessee
- *Preparation of short neutron pulses using the multi-MIEZE principle*
N. Arend, Technische Universität München
- *Detection of Protons in Neutron Decay Experiments: A Low Energy Proton Source for Detector Development*
R. L. Cooper, University of Michigan
- *UCN interaction with surface*
R. Golub, Hahn Meitner Institute, Berlin
- *A Gamma Polarimeter for Neutron Polarization Measurement in a Liquid Deuterium Target for Parity Violation in Polarized Neutron Capture on Deuterium*
M. Bowers, DePauw University
- *Development of a position sensitive neutron detector with high efficiency and energy resolution for use at high-flux beam sources*
D. M. Markoff, North Carolina State University
- *Bounds on P-odd T-odd interactions from polarized neutron capture with unpolarized targets*
C. R. Gould, North Carolina State University
- *High-precision measurements of the n - ^3He bound coherent scattering length*
P. R. Huffman, North Carolina State University/NIST
- *Environmental impact on the phase stability of a Neutron Interferometer*
S. Mayer, Atominstytut der Österreichischen Universitäten
- *A superconducting magnetic UCN trap for precise neutron lifetime measurements*
R. Picker, Technische Universität München, Germany
- *NIST Interferometer Facility for Precision Scattering Length Measurements*
D. L. Jacobson, National Institute of Standards and Technology

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