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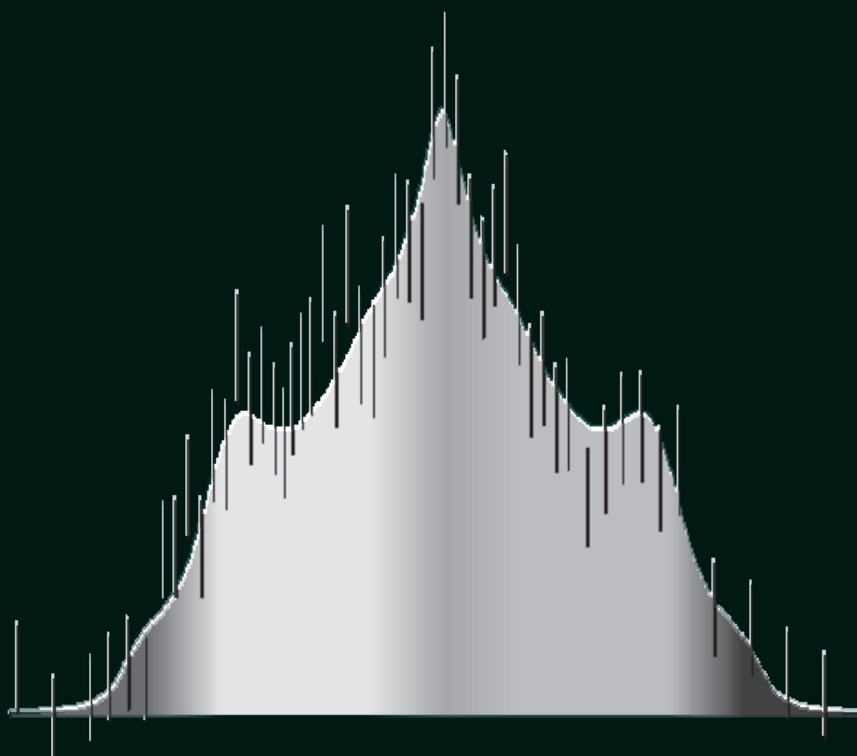
Special Issue: Applications of High-Precision γ-Spectroscopy



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- Electromagnetic Technology[1]
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- Information Access and User Interfaces
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- Distributed Computing and Information Services
- Software Diagnostics and Conformance Testing
- Statistical Engineering

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[1]At Boulder, CO 80303.
[2]Some elements at Boulder, CO.

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Cover: The profile on the cover illustrates the rich data available from high-resolution crystal spectroscopy. The gamma rays for this particular profile were produced in a $SrTiO_3$ single crystal oriented so that the <100> direction was parallel to the spectrometer axis. Following the emission of a primary gamma ray, the nucleus recoils. A second gamma ray can be emitted while the nucleus is in motion and its energy measured in the lab frame appears to be Doppler shifted. Due to the isotropic emission of the primary gamma rays, a broadening is observed rather than a shift. Because the atoms in the source are arranged in a periodic structure and oriented with respect to the spectrometer, neighboring atoms block certain recoil trajectories. The lifetime of the nuclear level and the inter-atomic potential, as well as the orientation of the source influence the shape of the Doppler broadened profile. This particular profile shows the experimental data and theoretical lineshape of the ^{49}Ti Doppler broadened gamma ray with E = 1498 keV. [M. Jentschel et al., Nucl. Instr. Meth. B**115**, 446 (1996).]

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, 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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Special Issue: Applications of High-Precision γ-Spectroscopy

Ani Aprahamian and Richard Deslattes

Articles

News Briefs

Note From the Chief Editor

Dear Reader,

Those of you who are familiar with the *Journal of Research of the National Institute of Standards and Technology* have no doubt noticed our new cover. The Board of Editors of the *Journal* and I thought that the start of the year 2000 was an appropriate time to change our appearance and to incorporate on the cover a photograph or other illustarion relevant to NIST and its work.

A brief description of the photograph or illustration will be found on the back of the title page. We hope that you find these of interest.

Barry N. Taylor
Chief Editor

Applications of High-Precision γ-Spectroscopy Papers Presented at the July 1998 Workshop at the University of Notre Dame

Preface

This Special Issue of the Journal of Research of the National Institute of Standards and Technology contains papers from an international workshop on the Applications of High Precision γ-Spectroscopy held on the campus of the University of Notre Dame, July 1-3, 1998. These applications extend from the study of nuclear level-schemes, level-lifetimes, and fundamental constants to investigation of atomic collision cascades, and the location of impurities in solids. Problems lending themselves to such investigations are seen to arise in astrophysics, nuclear, atomic, and condensed matter physics. The techniques and facilities used in these various applications range from semiconductor ionization spectrometers to crystal diffraction instruments while the measurements are carried out at accelerators, nuclear reactors, and/or spallation sources. The goal of this workshop was to provide a forum for the discussion and exchange of ideas on the present use and future developments of High-Precision γ-Spectroscopy.

The format of the workshop included a number of longer invited talks followed by contributed papers on a given topic with ample time allotted for discussions. This gathering included some 53 participants from 10 countries. Their numerous contributions can be seen in the following Program listing, and in the papers included in this Special Issue. A similar gathering had taken place previously on October 4-7, 1992, at the Institut Laue-Langevin (ILL) in Grenoble, France, where there were 60 participants coming from 12 countries. The changes in the scope and perspective between these meetings show increased diversity in the range of applications, a higher level of spectroscopic performance, extension of high resolution spectroscopy to higher energies, increased sophistication of the modeling procedure, and the practical realization of several opportunities whose potential could only be glimpsed at the time of the Grenoble meeting.

The very successful programs of γ-Spectroscopy at the ILL and elsewhere had certain limitations in the range of accessible energies, available resolution, and measurement accuracy. A new impetus in this area was provided by the successful development of GAMS4, a double-flat-crystal spectrometer operated as a joint facility at the High Flux Reactor of the ILL. The concept for the instrument was developed and tested at the National Institute of Standards and Technology [NIST—previously the National Bureau of Standards (NBS)] in the early 1970s. The earliest work was done with long-lived, relatively low-energy sources activated in the NBS reactor. There it was shown that high-resolution, high-accuracy γ-ray spectroscopy could be realized by a transmission geometry, two-crystal instrument, calibrated from first principles, and guided by laser-based angle interferometry.

The move to ILL was motivated by the need for prompt, high-energy, high-intensity sources available at the High Flux reactor with its higher neutron fluxes, and the possibility of having an in-pile source. The implementation, further development, and expansion of this concept at ILL was carried out through the joint and dedicated efforts of Ernest Kessler (NIST), Geoffrey Greene (NIST), M. Scott Dewey (NIST), and Hans Börner (ILL) in spite of the fact that the United States of America was not and is not a member of the ILL consortium of users. This long-standing collaboration between NIST and the ILL, involving significant sharing of the needed financial and human capital investments, has enabled the developments evident in this Special Issue on Applications of High-Precision γ-spectroscopy. While a significant portion of the papers included in this Special Issue result from the use of GAMS4, future benefits of a curved double-crystal spectrometer (GAMS5) seem very promising.

To the extent that the scientific contributors to this meeting have benefited from the capabilities offered by GAMS4, (and may be further benefited in the future by GAMS5), they, and we, are indebted to the successive Directors of the ILL over the past 20 years. Each of these directors, irrespective of his disciplinary perspective, has evidenced a broadly supportive view of the disparate character of the ILL enterprise, allowing it to include even the unusual body of work that is the subject of these proceedings. Finally, we acknowledge the generous financial support of the Graduate School, the College of Science, and the Department of Physics of the University of Notre Dame.

Richard D. Deslattes
Ani Aprahamian
Special Issue Editors

Applications of High-Precision γ-Spectroscopy

Program

Tuesday June 30, 1998

17:00 – 21:00 Reception and Registration

Wednesday July 1, 1998

Session Chair: A. Aprahamian—University of Norte Dame

9:00 – 9:50 R. D. Deslattes
High-Resolution γ-Spectroscopy: the First 85 Years

9:50 – 10:30 E. Kessler
Precision Measurements of Fundamental Constants Using GAMS4 I

11:00 – 11:40 M. S. Dewey
Precision Measurements of Fundamental Constants Using GAMS4 II

11:40 – 12:20 M. Jentschel
The GRID-Technique: Current Status and New Trends

Session Chair: C. J. Lister—Argonne National Laboratory

4:00 – 14:50 D. D. Warner
Nuclear Structure: The Future With Radioactive Beams

14:50 – 15:20 J. Doering
Low-Spin States From Decay Studies

15:20 – 16:00 R. Kruecken
Precision Lifetime Measurements Using the Recoil Distance Method

16:30 – 17:20 T. Glasmacher
High Resolution γ-Ray Spectroscopy With Fast Exotic Beams

17:20 – 18:00 C. Y. Wu
Sub-Nanosecond Lifetime Measurements Using the Recoil Distance Method

Thursday July 2, 1998

Session Chair: M. Jentschel—Institute Laue Langevin

9:00 – 9:40 K. H. Heinig
Gamma-Ray Induced Doppler Broadening Measurements With Single-Crystalline Targets (Crystal-GRID)—the Principles

9:40 – 10:20 N. Stritt
Study of Interatomic Potentials Using the Crystal-GRID Method on Oriented Single Crystals of Ni, Fe, and Cr

10:50 – 11:20 T. Koch
Study of Interatomic Potentials in ZnS: Crystal-GRID Experiments Versus Ab Initio Calculations

11:20 – 12:00 J. Jolie
Neutrino Induced Doppler Broadening

Session Chair: R. W. Hoff—Laurence Livermore National Laboratory

14:00 – 14:50 G. Mathews
Current Topics in Gamma-Ray Astrophysics

14:50 – 15:30 J. Goerres
Nuclear Structure and Galactic γ-Ray Activity

16:00 – 16:40 S. Robinson
GRID and the Study of Multiphonon States

16:40 – 17:10 F. Bevar
Simulations of γ-Cascades and Modeling Atomic Collision Chains

17:10 – 17:35 R. de Haan
Lifetimes of States in ^{178}*Hf*

17:35 – 18:00 R. Schwengner
Magnetic Rotation in the A=80 Region: M1 Bands in Heavy Rb Isotopes

Friday July 3, 1998

Session Chair: D. D Warner—Daresbury Laboratory

9:00 – 9:50 C. J. Lister
How far From Stability Can We Go Using Gammasphere and the FMA?

9:50 – 10:30 S. Yates
Electric Dipole Transitions and Octupole-Coupled Excitations in the Spherical Nuclei

11:00 – 11:40 N. V. Zamfir
Phonons and Phase Transitions in Finite Nuclei

11:40 – 12:10 W. Reviol
Measurements of Dynamic Electromagnetic Moments in Neutron-Deficient Nuclei

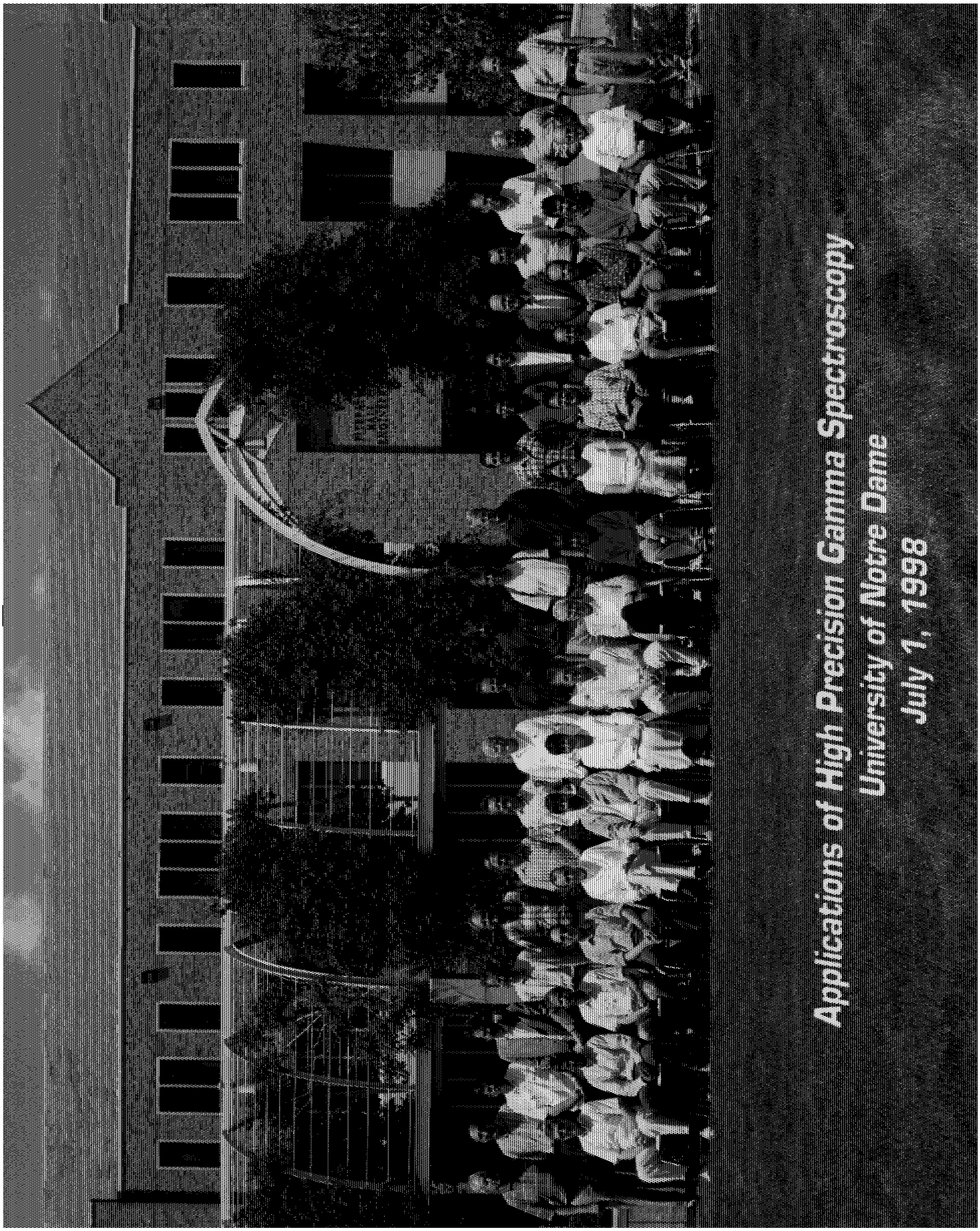
Session Chair: R. D. Deslattes—NIST

14:00 – 14:40 R. Moreh
New Nuclear Resonance Photon Scattering Studies of Molecular Adsorption and of Single Crystals

14:40 – 15:20 C. Doll
GAMS 5—*The New Gamma-Ray Spectrometer in Double-Dumond Geometry at the ILL*

15:50 – 16:30 G. Savard
High-Accuracy Mass Measurements of Trapped Radioactive Isotopes

16:30 – 17:10 D. Seweryniak
Studies of Nuclear Structure far From Stability Using Recoil-Decay Tagging and Related Methods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