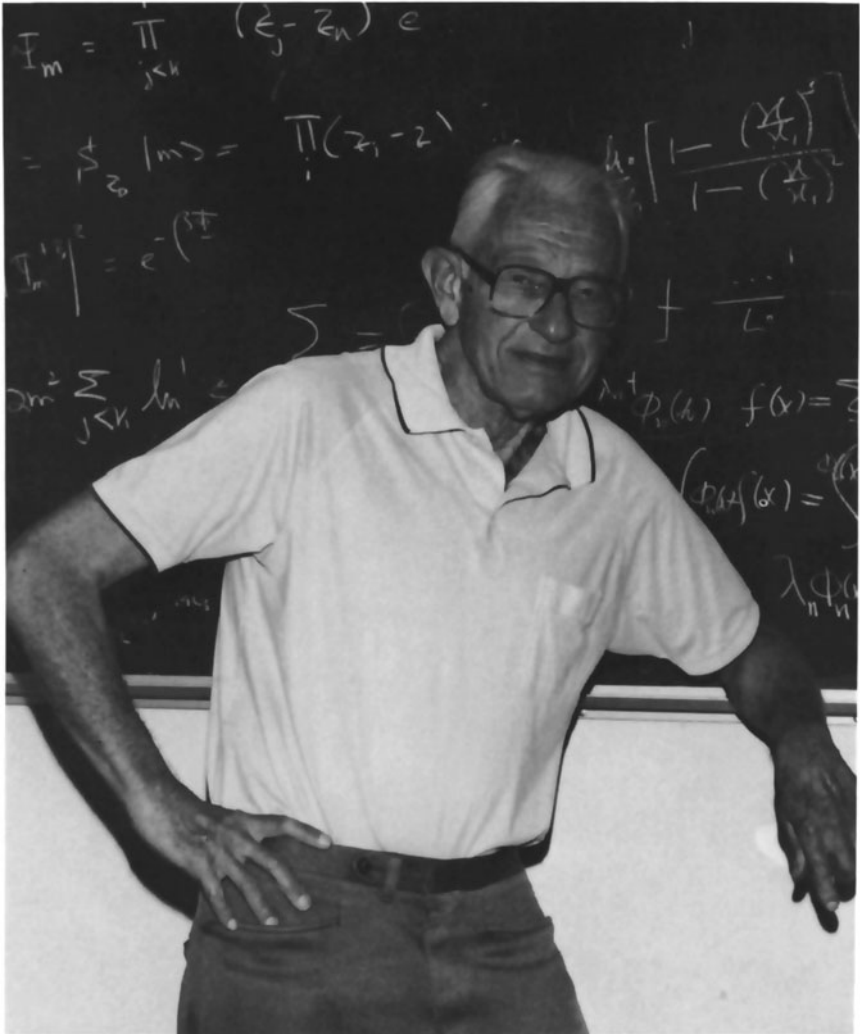


Condensed Matter Physics
The Theodore D. Holstein Symposium



Theodore D. Holstein

Raymond L. Orbach, Editor

Condensed Matter Physics

The Theodore D. Holstein
Symposium

With 71 Illustrations



Springer-Verlag
New York Berlin Heidelberg
London Paris Tokyo

Raymond L. Orbach
College of Letters and Sciences
University of California, Los Angeles
Los Angeles, CA 90024
U.S.A.

Library of Congress Cataloging in Publication Data
Theodore D. Holstein Symposium (1986: University
of California, Los Angeles)

Condensed matter physics.

1. Condensed matter—Congresses. 2. Polarons—
Congresses. 3. Electron-phonon interactions—Congresses.

4. Holstein, Theodore David, 1915–1985. I. Orbach, R.

II. Holstein, Theodore David, 1915–1985. III. Title.

QC173.4.C65T48 1986 530.4'1 87-9474

© 1987 by Springer-Verlag New York Inc.

Softcover reprint of the hardcover 1st edition 1987

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer-Verlag, 175 Fifth Avenue, New York, New York 10010, U.S.A.), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use of general descriptive names, trade names, trademarks, etc. in this publication, even if the former are not especially identified, is not to be taken as a sign that such names, as understood by the Trade Marks and Merchandise Marks Act, may accordingly be used freely by anyone.

Permission to photocopy for internal and personal use, or the internal or personal use of specific clients, is granted by Springer-Verlag New York Inc. for libraries and other users registered with the Copyright Clearance Center (CCC), provided that the base fee of \$0.00 per copy, plus \$0.20 per page is paid directly to CCC, 21 Congress Street, Salem, MA 01970, U.S.A. Special requests should be addressed directly to Springer-Verlag New York, 175 Fifth Avenue, New York, NY 10010, U.S.A. 96528-9/1987 \$0.00 + .20.

9 8 7 6 5 4 3 2 1

ISBN-13: 978-1-4612-9149-7

e-ISBN-13: 978-1-4612-4772-2

DOI: 10.1007/978-1-4612-4772-2

Preface

Theodore David Holstein died May 8, 1985, at the age of 69. His research career covered 46 years. His contributions have been seminal throughout this period, beginning with his first papers with H. Primakoff in 1939 and extending to the year of his death.

“Ted” earned his Ph.D. in physics from New York University in 1940, after earning his Master’s degree from Columbia University in 1936 and his B.S. from N.Y.U. in 1935. After receiving recognition while he was a graduate student for his contributions to the atomic theory of magnetism, he participated in the development of radar at the Westinghouse Research Laboratories, where he was a research physicist from 1941 to 1959. He taught on the faculty of the University of Pittsburgh from 1959 to 1965. He joined the Physics Department of the University of California, Los Angeles, where he remained until his death. Ted is survived by his wife Beverlee, his daughter Lonna Smith, his son Stuart, and his grandson Andy Smith.

Ted received many prestigious awards and honors, including membership in the National Academy of Sciences and the American Academy of Arts and Sciences. He received a von Humboldt fellowship for research at the University of Regensburg in the Federal Republic of Germany.

The Theodore D. Holstein Symposium was held in Ted’s memory on the campus of the University of California, Los Angeles, and at its Conference Center in Malibu, March 28–29, 1986. There were 73 attendees, spanning the research community from graduate students to Nobel Laureates. All were invited to contribute either original research articles or memorabilia to this volume. We are grateful to all those who have contributed to the Symposium, especially the financial support of the Westinghouse Research Laboratories and the University of California, Los Angeles.

Those of us who had the privilege of working with him know that we were all Ted’s “students.” We feel a profound emptiness which will not be filled. But Ted’s legacy of integrity and dedication will long remain. His scientific papers are classics: incisive, complete, and richly detailed. Many of them laid the foundation for all future work in their area and related areas. A glance at

his bibliography makes clear the contributions he has made to physics, and the reason so many of us are indebted to his scientific leadership.

Ted's thesis work with H. Primakoff in 1940 gave birth to the Holstein–Primakoff transformation which still forms the basis for treatments of spin-waves in ordered magnetic materials. His work on the imprisonment of resonant radiation in the late 1940s established a new field and is a model of clear, insightful analysis. It has been found useful not only for gases, but also for the solid state; not only for photons, but also for phonons. Ted's short article on the optical and infrared volume absorptivity of metals in the early 1950s has since been found to be fundamental for the analysis of the infrared absorption of normal metals and superconductors. Typically, the full work can be found in a Westinghouse unpublished report. Nevertheless, his short published article has had great impact.

This work was followed by half a decade of silence, to be broken by a veritable torrent of profound contributions. His calculation of the collision-drag effect laid the microscopic foundation for the beautiful macroscopic treatment of Pippard. His powerful and singularly successful series of papers on the polaron appeared the same year. Everyone who works on the polaron problem must make reference to these seminal papers. Again, at nearly the same time, he began a series of papers connected with the motion of a Bloch electron in a magnetic field. This led to the analysis of the Hall effect for impurity (hopping) conduction; high-frequency cyclotron resonance in an electron-phonon gas (with H. Scher); Hall mobility of the small polaron (with Lionel Friedman); the side-jump mechanism for the ferromagnetic Hall effect (with S.K. Lyo); the adiabatic theory of the Hall effect (with David Emin); the ferromagnetic Hall effect in the electron-phonon gas (with S.K. Lyo); and the ac ferromagnetic Hall effect (with S.K. Lyo). Taken together, these papers have had an impact on the entirety of the condensed matter field.

One of Ted's most elegant works is his study of the transport properties of the electron-phonon gas, some 149 pages in length, which appeared in the *Annals of Physics* in 1964. This monumental work, and especially its appendices, laid the foundation for the Boltzmann equation. It is a remarkably clear and complete work, and is a very effective textbook in its own right. It clearly displays his complete mastery of diagrammatics, and more important, his physical understanding.

In the mid-1970s, Ted clarified the microscopic basis of the Forster–Dexter theory of excitation transport in a series of papers (with S.K. Lyo and R. Orbach). This work forms the basis for the analysis of fluorescent line narrowing spectroscopy. His interest in spectroscopy led to the first successful microscopic theory for cooperative optical absorption (with S. Alexander and R. Orbach).

In the late 1970s, Ted began an extraordinary series of papers using a “simple” model to provide a quantitative and full expression for a chemical-rate theory of polaronic hopping. He then began a monumental series of papers exploring higher-order effects in hopping-type transitions of small polarons. This led to work completed just before his death on the motion of solitons in a dynamic

lattice (with B. Schutler). He approached the problem of phonon–soliton interaction in the same fashion which marked so much of his work. He introduced a “simple” model which exhibited all of the important physics and then proceeded to analyze it in extraordinary depth. The full physical content of the problem emerged quantitatively.

This listing does not do justice to Ted’s contribution to science. One must understand that the papers themselves are models of clarity. They bring order to subjects which previously had not been clear as to their microscopic basis. His work provided an inspiration to his generation, and to its students. It will remain a living monument; subsequent generations of scientists will turn to it for understanding and inspiration.

Ted’s memory will inspire us all. He was one of the leading theoretical physicists of his generation. He was the quintessential physicist, who did not tolerate sloppy thought in anyone’s work, especially his own. Ted was uncompromising in his search for understanding in physics.

It is for all these reasons that this symposium was organized. Those of us who were privileged to know and work with Ted hope that our contributions will acquaint others with his insight and accomplishments.

This volume is dedicated to his memory. We all miss him greatly.

Raymond L. Orbach
April, 1987

Contents

Magnetic Field Induced Transitions in Organic Conductors and Gaps in the Rings of Saturn <i>P.M. Chaikin, M. Ya Azbel, and P. Bak</i>	1
Today's Small Polaron <i>David Emin</i>	16
Electron-Phonon Coupling <i>T.H. Geballe</i>	35
The Random Field Problem; Facts and Fiction <i>V. Jaccarino</i>	47
Density Functional Theory of Excited States <i>Walter Kohn</i>	67
Attenuation of SAW Due to Electron Phonon Interaction <i>Moises Levy and Susan C. Schneider</i>	74
Close-Coupling Calculations of H ₂ /Cu (001) Scattering <i>B.H. Choi, N.L. Liu, and X. Shen</i>	82
Multiple Scattering in Semiconductor Quantum-Wells <i>S.K. Lyo</i>	98
Two Questions Raised by Simulations of the Hubbard Model <i>D.J. Scalapino</i>	103
Polarons and Subsurface Bonding <i>Ivan K. Schuller and M. Lagos</i>	110
New Directions in Calculating Electron-Phonon Interactions <i>Marvin L. Cohen</i>	116
The Electron-Phonon Cornucopia <i>J. Robert Schrieffer</i>	123

Magnetic Interaction in a 2-D Electron Gas <i>D. Shoenberg</i>	129
Reflections on Holstein's One-Dimensional Polaron <i>Leonid A. Turkevich</i>	142
Spin-Spin Interactions and Two-Dimensional Ferromagnetism <i>Y. Yafet</i>	155
Fractons and the Ioffe-Regel Limit <i>O. Entin-Wohlman</i>	160
REMINISCENCES	
Condensed Matter Physics: The Theodore D. Holstein Symposium <i>Philip W. Anderson</i>	176
My First Meeting with Ted Holstein <i>Marvin L. Cohen</i>	178
The Hall Effect Saga <i>Lionel Friedman</i>	180
Remembrances of Ted Holstein <i>Edward Gerjuoy</i>	184
A Few Remembrances of Ted Holstein <i>Bernd Schüttler</i>	186
Remembrance of Theodore D. Holstein <i>Lawrence A. Vredevoe</i>	187
Some Background to the Accomplishments of Ted Holstein <i>A. Theodore Forrester</i>	188

Contributors

PHILIP W. ANDERSON
Department of Physics
Jadwin Hall, P.O. Box 708
Princeton University
Princeton, NJ 08544

M. YA AZBEL
School of Physics and Astronomy
Tel Aviv University
Tel Aviv, Israel

P. BAK
Brookhaven National Laboratory
20 Pennsylvania St.
Upton, NY 11973

P.M. CHAIKIN
Department of Physics
University of Pennsylvania
Philadelphia, PA 19104

B.H. CHOI
Department of Physics
University of California, Riverside
Riverside, CA 92521

MARVIN L. COHEN
Department of Physics
University of California
and

Material and Molecular Research
Division
Lawrence Berkeley Laboratory
Berkeley, CA 94720

DAVID EMIN
Sandia National Laboratories
Division 3532
V.P. 1000, P.O. Box 5800
Albuquerque, NM 87185

O. ENTIN-WOHLMAN
Department of Physics
University of California, Los Angeles
Los Angeles, CA 90024
and
School of Physics and Astronomy
Tel Aviv University
Tel Aviv, Israel

A. THEODORE FORRESTER
(Deceased)
Department of Physics
University of California, Los Angeles
Los Angeles, CA 90024

LIONEL FRIEDMAN
Department of Electrical Engineering
Worcester Polytechnic Institute
Worcester MA 01609

T.H. GEBALLE
 Stanford University
 Stanford, CA 94305
 and
 Bell Communications Research
 Murray Hill, NJ 07974

EDWARD GERJUOY
 Department of Physics and Astronomy
 University of Pittsburgh
 Pittsburgh, PA 15260

V. JACCARINO
 Department of Physics
 University of California, Santa
 Barbara
 Santa Barbara, CA 93106

WALTER KOHN
 Department of Physics
 University of California, Santa
 Barbara
 Santa Barbara, CA 93106

M. LAGOS
 Facultad de Fisica
 Universidad Catolica
 Santiago, Chile

MOISES LEVY
 Department of Physics
 University of Wisconsin, Milwaukee
 P.O. Box 413
 Milwaukee, WI 53201

N.L. LIU
 Department of Physics
 University of California, Riverside
 Riverside, CA 92521

S.K. LYO
 Sandia National Laboratories
 Division 3532
 V.P. 1000, P.O. Box 5800
 Albuquerque, NM 87185

D.J. SCALAPINO
 Department of Physics
 University of California, Santa
 Barbara
 Santa Barbara, CA 93106

SUSAN C. SCHNEIDER
 Department of Electrical Engineering
 and Computer Science
 Marquette University
 Milwaukee, WI 53233

J. ROBERT SCHRIEFFER
 Institute of Theoretical Physics
 University of California, Santa
 Barbara
 Santa Barbara, CA 93106

IVAN K. SCHULLER
 Argonne National Laboratory
 9700 S. Cass Ave.
 Argonne, IL 60439

BERND SCHÜTTLER
 Department of Physics
 University of California, Santa
 Barbara
 Santa Barbara, CA 93106

X. SHEN
 Department of Physics
 University of California, Riverside
 Riverside, CA 92521

D. SHOENBERG
 Department of Physics
 University of Cambridge
 Madingley Road
 Cambridge CB3 0HE, England

LEONID A. TURKEVICH
 Standard Oil
 Corporate Research
 4440 Warrensville Center Road
 Cleveland, OH 44128

LAWRENCE A. VREDEVOE
Saint Johns Hospital
1328 22nd St.
Santa Monica, CA 90404

Y. YAFET
AT&T Bell Laboratories
600 Mountain Ave.
Murray Hill, NJ 07974