

A brief history of the Condensed Matter and Thermal Physics Group at Los Alamos through 2006

The group known today as Condensed Matter and Thermal Physics at Los Alamos National Laboratory has a history almost as long as that of Los Alamos itself. As our group arose out of the original Chemistry, Metallurgy Research (CMR) Division, and moved through Chemistry-Metallurgy Fowler (CMF), Physics (P), Energy (Q), back to Physics (P), then to Materials Science and Technology (MST), and most recently to Materials Physics and Applications (MPA), experimental condensed-matter science at cryogenic temperatures has remained its central technical focus, with thermodynamics a primary theme, and with additional themes of low-temperature physics and cryogenic engineering.

Milligram quantities of plutonium first arrived at Los Alamos in late 1943, and gram amounts in early 1944, so one can imagine the thrilling pace of physical-chemistry and metallurgical investigations of plutonium and some of its alloys in 1944 and early 1945, driven simultaneously by the unbelievable excitement of learning about a completely new element and by the urgent need to deliver the “pit” for Trinity, the first nuclear explosion.

After the end of World War II, many opportunities for fundamental science arose hand in hand with the ongoing development of nuclear weapons. The earliest members of our group initially teamed up to determine the properties of plutonium with high precision, recognizing that measurements of some of its properties at cryogenic temperatures were essential for developing an understanding of this very unusual metal as well as for accessing the practical issue of the thermal stability of properties below room temperature. These very early studies included isothermal compressibility, sound velocity, and thermal conductivity measurements that later were extended to electrical resistivity and specific heat. Thus the Metals Physics group was born at Los Alamos in 1945.



Figure 1. This sign has been hanging above the front door of our building for as long as we can remember. (Note: da Vinci was *not* a member of our group.)

Our group’s cutting-edge fundamental science and practical support for the mission of Los Alamos Scientific Laboratory expanded in the late 1940s with a new applied focus: the so-called “Super,” using a fission trigger to unleash the energy of fusion of light nuclei. It was known that deuterons fuse much more easily than protons and that a high initial density of deuterons was advantageous, so it was obvious that research on the fundamental properties of cryogenic liquid deuterium would be needed, as well as engineering research into the separation and purification of the hydrogen isotopes and the liquefaction, storage, and transport of deuterium. Tritium—the

radioactive isotope of hydrogen—was also of interest. In 1948, our group was renamed Low Temperature Physics and Cryoengineering, and undertook a systematic scientific and engineering study of the low-temperature thermodynamic and transport properties of all the helium and hydrogen isotopes. This fundamental work was punctuated by the “Mike” shot at Eniwetok atoll, using liquid deuterium fuel and producing a thermonuclear yield of roughly 10 megatons of TNT. (See Figure 2.)

The record shows that many group members of that era somehow accomplished both fundamental research and meaningful participation in Mike and other south-Pacific weapons tests. When our group’s new building, shown in Figure 3, was opened in the mid 1950s, the street in front was named Eniwetok in memory of those intense years of work. Although cryogenic liquid deuterium was soon replaced by room-temperature solid lithium deuteride as the fuel for thermonuclear weapons, the extensive low-temperature science and engineering associated with Mike underpinned other important future developments ranging from the use of liquid hydrogen as space-shuttle fuel through the development of standards for safe handling of large quantities of cryogenic liquids to the physics of superfluid helium.

To appreciate the scientific excitement of low-temperature physics in this era, one should remember that helium superfluidity was not discovered until 1937-38 and the two-fluid model of superfluidity was not established until the late 1940s. As had been the case with plutonium a few years earlier, with ^3He our group took advantage of the unique opportunity to explore the



Figure 2. Mike, the first large-scale experiment with thermonuclear fusion. 1952. Photo courtesy of National Nuclear Security Administration / Nevada Site Office.



Figure 3. The buildings that still hold most of our group, as they appeared in 1957 when the only other nearby buildings were the CMR building (left), the administration building (background), and the steam plant (right background). SM32 (known then as the Cryogenic Engineering Laboratory) and SM34 (known then as the Low Temperature Physics Laboratory) had a much higher ratio of lab space to office space than is typical in today's new construction. Parts of the sawtooth roof on the east end of SM32 were deliberately weak — potential sacrifices, to save the rest of the building in case of explosion during the years that they housed hydrogen liquefaction equipment.

properties of an entirely new material, motivated by and enabled by applied work. The natural abundance of ^3He is tiny, but thermonuclear weapons production established a new, industrial-scale production of tritium, which decays with a 12-year half-life into ^3He , giving our group the first access to this fascinating and complex solid and liquid. Our group accomplished the historic initial liquefaction of ^3He in 1948 and performed measurements of its thermodynamic and transport properties throughout the 1950s.

Remember, too, that this was an era when most research equipment was still built by technicians — not bought from companies — and experiments were still done by people — not by computers. Each cryostat and its associated plumbing were individually designed and carefully built. Data acquisition rates and accuracy were usually limited by how well group members could read mercury manometers, analog galvanometers, and optical levers with linear scales, and how quickly and accurately they could write the numbers in their lab books. Temperatures were held constant by homemade rubber-membrane manostats regulating the pressure in pumped helium baths, or in rare, sophisticated circumstances by homemade electronic feedback circuits using vacuum tubes. Data analysis relied mostly on pencils, paper, and slide rules. (Later, a lab book might occasionally be taken to the ladies whose job it was to transcribe data onto IBM punch cards for processing at the central computing facility.) Secretarial skill was measured by the number of typing errors per page of technical manuscript, a number that was often far smaller

than one, despite staff member handwriting that made the distinctions between words like “monatomic” and “monotonic” a matter of judgment for the typist.

By the mid 1960s, the “Low Temperature Group” included 10 physicists, 9 physical chemists, 7 technicians, 5 chemical engineers, 4 machinists, 2 mechanical engineers, 2 secretaries, 2 postdocs, and 1 electrical engineer. Already, a tremendous breadth of interests in low-temperature physics was evident: Scientific studies underway included equation of state and thermal properties of the helium isotopes, neutron diffraction studies of solidified gases, superfluid hydrodynamics, superconductivity, Mossbauer studies of lattice dynamics and magnetism, the Kondo effect, and nuclear physics with cryogenic polarized targets. Cryogenic engineering research and development in that era included measurement of transport properties of helium and hydrogen liquids, the design and construction of several superconducting magnets and radio-frequency cavities for use elsewhere at Los Alamos, and solid hydrogen and deuterium target development for the Los Alamos Meson Physics Facility. At the interface between low-temperature physics and cryogenic engineering, our group had the first working ^3He - ^4He dilution refrigerator in the US, thanks to the technician who assembled it perfectly leak-free on his first attempt; and one of our early dilution refrigerators stayed cold for three months, which was a remarkable accomplishment at that time.



Figure 4. Our group’s machine shop has changed little through many decades, until the present era of numerically controlled machines. Under microscopic examination, the calendar on the left in this photo displays January 1964, and the floor in the foreground is littered with doughnut crumbs — evidence that our traditional celebration of the exceptional work of our group’s technicians goes back at least 43 years.

Our group leaders

1945–1970	Ed Hammel	(Ph.D. physical chemistry, Princeton, 1944)
1970–1985	Bill Keller	(Ph.D. physical chemistry, Harvard, 1948)
1985–1992	Bob Heffner	(Ph.D. physics, Washington, 1973)
1992–2001	Joe Thompson	(Ph.D. physics, Cincinnati, 1975)
2001–2002	Art Ramirez	(Ph.D. physics, Yale, 1984)
2002–2006	John Sarrao	(Ph.D. physics, UCLA, 1993)
2006–	Mike Hundley	(Ph.D. physics, Berkeley, 1988)

In the 1970s, a new national need gained attention, and our group responded again with a combination of fundamental research and technology development. The 1973 OPEC oil embargo triggered the widespread realization that US energy sources were being depleted and imported energy was undependable; furthermore, acid rain and other pollution were problematic. Many group members naturally carried their low-temperature-physics and cryogenic-engineering talents into energy R&D. Fundamental work included research on flux motion, losses, and pinning in Type II superconductors, dielectric breakdown at cryogenic temperatures, properties of A15 superconductors (e.g., Nb₃Ge), and the stability of superconductor/normal-metal composites, while applied efforts included the development of dc and ac superconducting power transmission lines, superconducting magnetic energy storage for electric utilities, a car fueled by cryogenic hydrogen, and cryogenic distillation purification of hydrogen isotopes for fusion-energy fuel. Federal support for such energy R&D dropped abruptly in the early 1980s, but many of these developments are receiving renewed attention today, and significant spin-offs from that era of our group, such as the Los Alamos Tritium Systems Test Assembly, now have significant histories of their own.

In the late 1970s and early 1980s, the study of thermodynamic cycles and processes, and the relevant properties of materials used in them, began with an effort in magnetic refrigeration and later included engines and refrigerators using liquids near their critical points. Advances in magnetic refrigeration quickly took that team out of our group and into industry. ³He–⁴He mixtures below 1 Kelvin proved to be ideal for studying the fundamentals of yet another type of thermodynamic process: spinodal decomposition of supersaturated phase transitions. Another aspect of our group's focus on cycles and processes, the development of the fundamentals and applications of thermoacoustic engines, refrigerators, and (later) mixture separators, began in 1981 with the invention of the thermoacoustic refrigerator in our group. In the 1990s, the thermodynamic-cycles and -processes focus grew further to include the invention and development of tiny hollow, spherical, cryogenic deuterium–tritium shells for inertial-confinement fusion targets, an effort which soon matured and moved out of our group.

The early to middle 1980s was a transitional period for fundamental research in our group, refocusing on more-fundamental problems in fluid dynamics and on strongly correlated f-electron phenomena. Appropriate to this change in fundamental focus and to the continuation of thermodynamic-cycle and -process research, our group's name was changed to Condensed Matter and Thermal Physics. Correlated-electron phenomena, fundamentals of fluid dynamics, and thermoacoustics remain central research themes of our group today.

The fluid-dynamics focus of the 1980s included an experimental program in chaos, pattern formation, and turbulence, which continues today. Still based in part on low-temperature techniques, the fluids focus also served as an incubator for a cryogenic neutrino-mass experiment based on spin-polarized hydrogen in the 1980s. In the 1990s, the fluids focus expanded to include the study of lead-bismuth mixtures and other liquids, and their interactions with steels, of interest in advanced nuclear reactors and the accelerator transmutation of nuclear waste; and the thermoacoustics team began the development of thermoacoustics for industrial-scale liquefaction of natural gas.

The research focus on correlated-electron materials, their growth as single crystals, and earlier experience with applications of superconductors positioned our group to respond immediately to the 1986 discovery of high-temperature superconductivity. As in many other laboratories around the world, this discovery marked a sea change in our group and triggered the expansion of experimental capabilities necessary to explore and understand this surprising phenomenon. By the end of the 1980s, these capabilities included electronic transport, thermodynamics, heat transport, and nuclear-magnetic and muon-spin resonance. Los Alamos, like the rest of the nation, saw high-temperature superconductivity as an opportunity to reinvigorate energy-related research, and formed the Superconducting Technology Center from a nucleus of group members to develop applications of this discovery. Fundamental research on strongly correlated electron physics, including f-electron and cuprate materials, remained in our group and provided a basis for Los Alamos to collaborate with the state of Florida in establishing the new National High Magnetic Field Laboratory. With our group's interests in the physics of correlated materials at

Our group's American Physical Society Fellows

Al Arko
Larry Campbell
Greg Dash
Bob Ecke
Zack Fisk
Chris Hammel
Ed Hammel
Bob Heffner
Bill Keller
Marty Maley
Al Migliori
Roman Movshovich
Bill Overton
Art Ramirez
John Sarrao
Adam Schuch
Bill Steyert
Greg Swift
Toni Taylor
Joe Thompson

Our group's Laboratory Fellows *

Al Arko
Bob Ecke
Zack Fisk
Chris Hammel
Al Migliori
Bob Mills
Greg Swift
Joe Thompson
John Wheatley ‡

* Los Alamos Fellows established in 1981
‡ Joint Los Alamos-UCLA Fellow

extremes of low temperatures and high pressures, it was natural for the newly created Los Alamos Pulsed Field Facility to find its home in our group until 1998, when the Magnet Lab was spun off as a separate Laboratory Center.

During the 1990s, our group also diversified into ultra-fast optics (which opened new windows for investigating correlated-electron materials but also impacted weapons diagnostics), started an effort in magnetic resonance force microscopy, and added neutron scattering and photoemission to its growing repertoire of materials-characterization techniques. These years laid the foundation for the 2002 discovery in our group of the first plutonium-based superconductor, a direct result of our earlier work on related heavy-fermion superconductors and magnets. With this discovery and with photoemission research, part of our group returned to its roots in the study of plutonium. Despite its continuing relevance to the Los Alamos's mission, relatively little progress had been made on fundamental understanding of the "plutonium problem" during the previous six decades, but superconductivity in the new plutonium compound opened entirely new avenues for investigation and engaged the international condensed-matter community in plutonium for the first time.

Summarizing the activities of hundreds of people over the course of 60 years in such a short note is a matter of brutal down-selection. Many precious memories are unrecorded here; entire lines of research whose stories could each occupy many pages have been completely omitted. Nevertheless, we hope this short note communicates the pride that we feel for the history of our group, for its responsiveness to the applied needs and the scientific frontiers in each decade of its existence, and for its enduring commitment to technical excellence.

Greg Swift and Joe Thompson, 2006

(We gratefully acknowledge documents and stories from Ed Hammel, Dean Taylor, Jim Hoffer, and Marty Maley.)

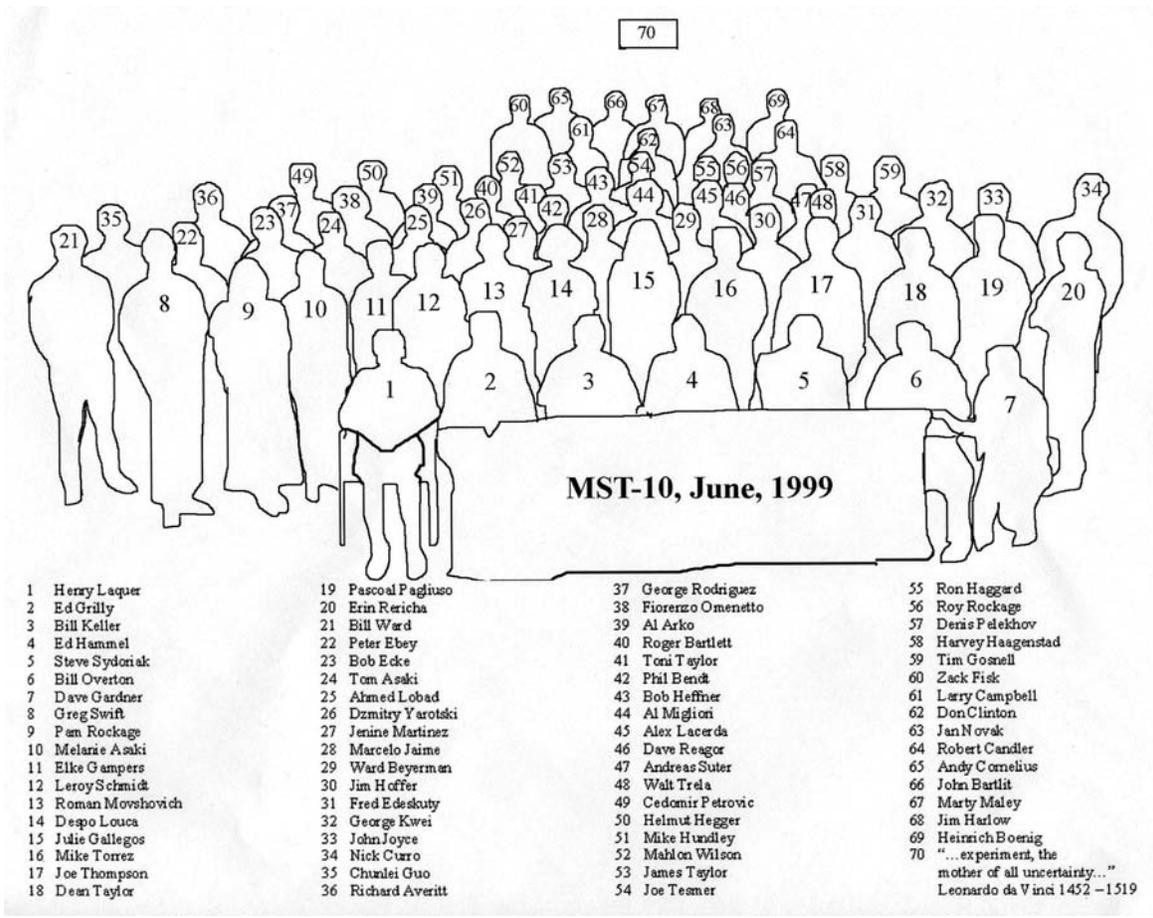


Figure 5. Our group reunion in 1999.

CMR-9 CMF-9 P-8 Q-26 Q-10 P-10 MST-10 MPA-10

'45 - '55

'56 - '70

'70 - '72

'73 - '77

'77 - '79

'80 - '93

'94 - 2006

'06 - 07 - ??

Present staff members

Scott Backhaus (p)

Wei Bao

Eric Bauer (p)

Nick Curro (p)

Tomasz Durakiewicz (p)

David Gardner

Mike Hundley (p)

John Joyce (p)

Jackie Kiplinger (p)

Ning Li (p)

Roman Movshovich (p)

Mike Rivera (p)

Filip Ronning (p)

Greg Swift (p)

Joe Thompson (p)

Former staff members (Date ranges are years in our group; Los Alamos presence may be longer.)

Al Arko

Rick Averitt

Bill Ball

John Barclay

Roger Bartlett

John Bartlit '62-'80

Phil Bendt '56-'72

Hans Bevens '45-'48

Heinrich Boenig

John Bronson

Larry Campbell (p)

'67-80 & '95-98

Dick Carlson (p)

Prit Choudhuri

Jack Conant

Paul Craig

Tim Darling (p)

Greg Dash '51-'60

John Dean '74-'79

Bob Ecke (p)

Fred Edeskuty '50-??

Anatoly Efimov (p)

?? Faveuff

Zach Fisk (s)

Tim Gosnell

Ed Grilly '47-'80

Chris Hammel (p)

Ed Hammel '45-'70

Bill Hassenzahl

Bob Heffner (p)

Mike Henke

Jim Hoffer '70-'01(p)

Charlie Hoffman

Chester Hwang

Chou Yen Huang

Il-Kyoung Jeong (p)

Kamal Khallafala

Bill Keller, '50-'85

Gene Kerr

Tsuyoshi Kimura (p)

Tom Kitchens (p)

George Kwei

Alex Lacerda (p)

Henry Laquer '47-'77

Don Liebenberg

Don Lester

Jim Lindsay

Earl Long

Marty Maley (p)

'65-67 & '74-89

Tom McDonald

Albert Migliori (p)

Bob Mills

Gil Miranda

Jan Novak '60-'70

Bill Overton

Denis Pelekhov (p)

Cal Potts

Art Ramirez

Jeff Roberts

Tom Roberts

George Rodriguez (p)

John Rogers '51-'92

Ray Rylander

Tom Sandenaw

John Sarrao (s)

Dave Schiferl (p)

Adam Schuch '49-'??

Al Sesonke

Bob Sherman

Bob Shermer

Henry Sommers

Walt Stewart

Bill Steyert

Bob Stokes

John Sullivan

Steve Sydoriak '48-'80

Dean Taylor '54-'90

Toni Taylor

Joe Tesmer

Walt Trela

John Wheatley '81-'86

Ken Williamson

Walt Willis '60-'??

Jeff Willis (p)

Mahlon Wilson '65-'67

Stefan Wipf

(p) – initially hired as a postdoc

(s) – initially hired as a student

Roster revision history:

2000 JKH; 2006 GWS and JA

1/20/2007

Present technicians and machinists

Carmen Espinoza	Warren Pierce	Mike Torrez
Kevin Graham	Roy Rockage	Todd Womack

Former technicians and machinists

Bob Aiken	Stretch Fretwell	Robert Martinez
John Bailey	Eleutario Garcia	Candido Maestas
Thom Bell	Guadalupe Garcia	Eldon Murley (?)
Marcus Bennett	Barney Geelan '51-'83	Bob Oziemski
Johnathan Betts	Ron Haggard	Tim Pierce
Art Briesmeister	Dean Harkleroad	Ernesto Romero
Dick Briesmeister	Clarence Harmer	Jen Roper
Bob Candler	Doug Hatch	Ray Rylander
Don Clinton	Jim Harlow '48-'78	Leander Salzer
Bob Chrisman	Harvey Haagenstad	Paul Saunier
Bob Cole	Joe Hand	Leroy Schmidt
Yates Coulter	Bob Johns	Bob Stokes
Sam Cunningham	Joe King	James Taylor '63-'81
Glen Dill	Epolito Lopez	Ike Valdez
Jack Dyson	Mike McClannahan	Sherman Vernon
Albert Eisensee	Willard McCormick	Jimmy Wade
Chris Espinoza	Quinn McCulloch	Gerry Weeks
Caleb Evans	Jimmy Martinez	Bill Yeamons
Harry Ficht	Joe Martinez	

Present secretaries and administrators

Juanita Armijo

Former secretaries and administrators

Judy Ackerhalt	Adeline Damiano	Melanie Maestas
Maxine Beckmann	Stephanie Davis	Vicky Maestas
Peg Bivins	Gin Desjardin	Manuelita Mtz-Brito
Virginia Brennan	Judy Gallegos	Lou Miller
Michelle Brewer	Julie Gallegos	Shirley Montoya
Judi Briesmeister, '74-'76	Claire Gillis	Nancy Morrison
Sylvia Charmatz	Helen Hansen	Pam Rockage
Betsy Coca	Carol Harkleroad	Norma Stibbard
Mary Curfman	Eunice Kern	Nissa Strottman

Present post docs and students (“s” indicates student)

Mahesh Bandi	Tomasz Klimczuk	Yoshi Tokiwa
Tod Caldwell	Han-Oh Lee	Mike Twardos
Jun Chen	Evgueni Nazaretski	Ricardo Urbano
John Clark (s)	Tuson Park	
Peter Hoseman	Eric Schelter	

Former post docs and students (“s” indicates student) who are not listed elsewhere.

Clint Ackerman	Matt Eisaman (s)	Ken Krane
Jason Alexander (s)	John Engelhardt	Raymond Kwok (s)
Ballard Andrews	Dennis Erickson	Lianping Le
Meigan Aronson	Arshang Fartash (s)	Hae Ja Lee
Marie Aronsson	Franz Freibert	Ming Lei
Melanie Asaki (s)	Jim Fraser	Jason Leonard (s)
Fedor Balakirev	Veronika Fritsch	Rich LeSar
Marty Banton	Andy Fusco	Jon Levine (s)
Ward Beyermann	Brian Gamble (s)	K.C. Lim
Simon Billinge	Elke Gampers (s)	Ana Lima
Robert Blyth	Jason Gardner	Scott List
Corwin Booth	Drew Geller	Yuanming Liu
Hortencio Borges	Tom Graf	Anna Llobet
Tamas Borzsonyi	Chunlei Guo	Ahmed Lobad
Steve Boyd (s)	(Dave?) Haensch	Despo Louca
J. Boyer	Mike Hayden	Mary Lowe
Tim Braje (s)	Hans Haucke (s)	McLean Machut
Theresa Brandman (s)	Kaden Hazzard (s)	Yoshi Maeno (s)
John Brisson	Helmut Hegger	David Mandrus
Stuart Brown	Jerry Helfrich (s)	Joe Martindale
Scott Buchanan	Jeff Hill	Janine Martinez (s)
Lou Bucholtz	Bob Hiller	Karlene Maskaly (s)
Francesca Calgaro	David Hilton	Joe Matthews (s)
Keith Carroll	Daniela Hristova (s)	Konstantin Matveev
Paul Canfield	Tom Hofler (s)	Pat Maxton (s)
Bill Challener	Yuchou Hu	Mike McHenry
Houtang Chen	Namjung Hur	Chuck Mielke
Sang Cheong (s)	Randy Jacobs (s)	Robert Modler
Elbert Chia	Marcelo Jaime	David Moore
H. Coburn	Kimberly Jantunen	Greg Moore
Andy Cornelius	Del Jones	Mark Moores (s)
Gary Cort	Ki-Yong Kim	Evangelia Moshopoulou
Zahir Daya	Yongmin Kim	Karl Mueller
Giovanni Donati (s)	Padma Kodali	Carl Mungan
Peter Ebey	Vince Kotsubo	John Neumeier

CMR-9 **CMF-9** **P-8** **Q-26** **Q-10** **P-10** **MST-10** **MPA-10**
 '45 - '55 '56 - '70 '70 - '72 '73 - '77 '77 - '79 '80 - '93 '94 - 2006 '06 - 07 - ??

Michael Nicklas	Larry Schwalbe	Andreas Suter
Fenglei Niu	John Shier	Verner Thorsmolle
John Norvell	Shoou-Shinn Shiah (s)	Rod Thurston
John O'Hara	Craig Siders	Peter Vorobieff
Jeff Olson	Jenifer Siders	Bill Ward
Fiorenzo Omenetto	Barb Simovic	Atsu Watanabe (s)
Willie Padilla	Dipen Sinha	Dzmitry Yarotski (s)
Pascoal Pagliuso	Jim Sites	Balakishore Yellampalle
Cedomir Petrovic (s)	Bart Smith	Yohsuke Yoshinari
Long Pham (s)	Mike Smith	Ben-Li Young
Rohit Prasankumar	Jin So	Huidan Yu
Bill Pratt	Jeff Sonier	Zhenyong Zhang
Andrea Prodi (s)	Guenter Sparn	Fang Zhong
Dave Reagor	Phil Spoor	E. Zirngiebl
Bob Reid (s)	Andrew Stockham (s)	Bob Ziff
Erin Rericha (s)	Thor Stromberg	Carl Zimm
Arneil Reyes	Byong Jin Suh	
Brandon Rohrer	Tim Sullivan	

Present long-term visiting staff members/consultants/collaborators

Tim Darling	Bob Heffner	Vladimir Sidorov
Leticie Ferreira	Jon Lawrence	Dean Taylor
Zach Fisk	Moshe Pasternak	

Former long-term visiting staff members/consultants/collaborators whose names do not appear elsewhere

Bernie Abraham	Hans Frauenfelder	Bob Leisure
Paul Barrett	Louis Goldstein	Doug MacLaughlin
Jacob Bigeleisen	Lenny Gruenberg	Dillon Mapother
Ferdinand Brickwedde	George Gruner	Darrell Osborne
Bob Brout	Bob Hake	Hans Ott
Ludwig Bruch	A. Hildebrandt	Ron Parks
John Clem	Dieter Hochheimer	C. B. Pierce
Eddie Cohen	Col. Hutchinson	Philippe Pruzan
Michael Cohen	Elisha Huggins	John Raich
Heikke Collan	Hubert James	Roger Shaw
John Daunt	Henry Kierstead	John Sheliak
Daniel Decker	John Kilpatrick	Sergei Stishov
Mel Daybell	Myra Kilpatrick	Masashi Takigawa
Yehiel Disatnik	Matti Krusius	Hirofumi Wada
Dick Etters	Sig Larsen	Bernie Weinstock
Henry Fairbank	Elliott Leib	Gene Wells