



Jack Freed: On the Occasion of His 80th Birthday

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Published online: 8 October 2018

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It is with great pleasure that we present the magnetic resonance community with this special issue commemorating the 80th birthday of Prof. Jack H. Freed. J. H. Freed, Professor Emeritus of Chemistry at Cornell University, was born in New York City, on April 19, 1938. After graduating from Stuyvesant High School (1954), he attended Yale University, receiving his B.E. degree in 1958, graduating first in his class with the highest honors. He pursued his graduate studies at Columbia University with Professor G. K. Fraenkel and received his M.S. in 1959 and his Ph.D. in 1962. During 1962–1963 Dr. Freed was a Postdoctoral Fellow at Cambridge University. In 1963 he accepted a faculty appointment at Cornell University, where he has spent his subsequent career (Assistant Professor, 1963–1967; Associate Professor, 1967–1973; Professor, 1973–2007; Frank and Robert Laughlin Professor of Physical Chemistry (2007–2016); and Professor Emeritus, 2016–). He has been director

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of the National Biomedical Center for Advanced ESR Technology (ACERT) since 2001.

Prof. Freed is one of the true pioneers in the field of magnetic resonance and undoubtedly a leader in electron spin resonance (ESR). Almost any major topic of research in ESR, both theoretical and experimental, has been either explored or described by one of the many papers he published. His seminal contribution to the field started during his graduate studies with Prof. Fraenkel in the early 1960s, with a paper describing the anomalous alternating linewidths in the ESR spectra of anion radicals. This work led to what is now known as the Freed–Fraenkel theory of ESR linewidths and formed the basis of his subsequent comprehensive theory of the phenomena of ESR saturation and electron–nuclear double resonance (ENDOR) later in the 1960s. In this context, it is important to note that his important insights revealed in a series of papers from the late 1960s, entitled “Theory of Saturation and Double Resonance Effects in ESR Spectra”, led to the development and applications of the electron–nuclear triple resonance (TRIPLE) technique.

While initially the main focus of Prof. Freed’s work was of a theoretical nature, soon after he came to Cornell he also started to work on advanced experimental aspects of ESR, such as continuous wave and pulsed electron–electron double resonance (ELDOR). In parallel with setting up a first class experimental laboratory, he continued to dwell deep into ESR theory. The question that was high on the agenda of the scientific community was how to interpret the strange, seemingly almost arbitrary, shape variations apparent in the ESR spectra of stable radicals in solution, especially when their motion is restricted. The solution came out in the form of Prof. Freed’s famous method for ESR lineshape calculations using the stochastic Liouville equation (SLE). The numerical solution of the resulting expressions turned out to be extremely computationally intensive, especially with the compute power available in the late 1970s and early 1980s, which necessitated a range of mathematical developments, unique in their own, just to cope with this aspect of the problem. Eventually, this SLE approach matured in the late 1990s and is now used extensively to interpret many of the ESR spectra obtained in many laboratories worldwide.

During the 1980s and the 1990s, the laboratory of Prof. Freed pioneered a pack of new ESR experimental methodologies, such as two-dimensional pulsed ESR and high-field ESR. The former included pulse sequences that were adapted from NMR, such as COSY and SECSY, but were considered an impossible feat for ESR due to its much shorter relaxation times, much higher microwave frequencies, and the complicated theory needed to properly interpret the results of these experiments. Prof. Freed and his group overcame all these challenges and this has resulted in techniques such as 2D ELDOR, which serves as a cornerstone in the exploration of molecular dynamics. In the late 1990s, he also published the first few papers that showed the potential of ESR to measure large interspin distances.

At the turn of the new millennium, the research of Prof. Freed received a huge boost with the establishment of his NIH-funded advanced center for ESR technology (ACERT). Within the framework of ACERT activity, many new methodologies were developed, improved, and applied primarily to a variety of biologically related research issues. This includes methods such as double quantum coherence ESR for distance determination, pulsed high-field ESR, ESR microscopy, and multifrequency

ESR studies to reveal the complicated dynamics of macromolecules at different time scales and a variety of signal processing methods to analyze and denoise ESR data. This wide arsenal of methods has been used in recent years to solve long-standing questions in structural biology, leading to several impactful papers in *Nature*, *Science*, and *PNAS*.

Through his works Prof. Freed continues the excellent scientific tradition that traces back to the sixteenth century. If we trace back his “academic ancestors”, we find that the mentor of his PhD instructor (Prof. Fraenkel) was the Nobel Laureate Prof. Peter Debye. In turn, Debye’s instructor was the great physicist, Prof. Arnold Sommerfeld, who was himself instructed by the German mathematicians Prof. Ferdinand Lindemann. The latter trained under Prof. Felix Christian Klein. From here on, we find famous mathematicians such as Rudolf Lipschitz, whose instructor was Gustav Peter Lejeune Dirichlet with his two academic “fathers” Fourier and Poisson, and then Lagrange and Laplace, leading to d’Alembert: overall, a truly remarkable academic tree which evidently led to a truly remarkable scientific career.

Prof. Freed has received many honors for his scientific activity, as listed below, and has instructed almost 40 graduate students and 70 postdocs (listed below). Clearly, this short preface cannot accommodate all the scientific achievements of Prof. Freed. Yet, we hope this serves as an appetizer for reading the papers gathered in the two volumes of this special issue, many of which touch upon the subjects that were at the focus of Prof. Freed’s activity. Before concluding, we want to wish Jack many more years of good health and scientific creativity and much “Nachath” from his family—his ever-loving wife Renée, his daughters Denise and Nadine and his lovely grandchildren.

Biographical Sketch

J. H. Freed, Professor Emeritus of Chemistry at Cornell University, was born in New York City, on April 19, 1938. After graduating from Stuyvesant High School (1954), he attended Yale University, receiving his B.E. degree in 1958, graduating first in his class with the highest honors. He pursued his graduate studies at Columbia University with Professor G. K. Fraenkel and received his M.S. in 1959 and his Ph.D. in 1962. During 1962–1963, Dr. Freed was a Postdoctoral Fellow at Cambridge University. In 1963 he accepted a faculty appointment at Cornell University, where he has spent his subsequent career (Assistant Professor, 1963–1967; Associate Professor, 1967–1973; Professor, 1973–2016; Professor Emeritus, 2016–); Frank and Robert Laughlin Professor of Physical Chemistry (2007–); and became Professor Emeritus as of July 1, 2016. He has been director of the National Biomedical Center for Advanced ESR Technology (ACERT) since 2001.

Professor Freed is a world-renowned expert in the field of magnetic resonance, especially electron-spin resonance (ESR). He is the author or co-author of over 400 publications.

List of Fellowships, Awards, and Professional Activities

Honorary U.S. Ramsay Memorial Fellow (1962–1963)

NSF Postdoctoral Fellow Cambridge University (1962–1963)
A.P. Sloan Foundation Fellow (1966–1968)
Visiting Scientist, U.S.–Japan Cooperative Science Program, Tokyo University (1969)
Senior Weizmann Fellow, Weizmann Institute of Science (1970)
Guest Professor, Aarhus University (1974)
Chairman, Gordon Research Conference on Magnetic Resonance (1975)
Board of Editors, *Journal of Chemical Physics* (1976–1978)
Fellow of the American Physical Society (1976)
Visiting Professor, University of Geneva (1977)
Visiting Professor, Delft University of Technology (1978)
Editorial Advisory Board, *Journal of Physical Chemistry* (1979–1983)
Buck-Whitney Award of the American Chemical Society (1981)
John Simon Guggenheim Memorial Fellow (1984–1985)
Visiting Professor, L'École Normale Supérieure, Paris (1984–1985)
Advisory Editorial Board, *Chemical Physics Letters* (1988–1990)
Bruker Award and Lecturer, The Royal Society of Chemistry (London, 1990)
Editorial Board, *Applied Magnetic Resonance* (1990–2016)
Fellow of the Institute for Advanced Studies, The Hebrew University of Jerusalem (1990)
Visiting Professor, University of Padua (1991)
Gold Medal Award of the International Electron Spin Resonance Society (1994)
Editorial Board, *Magnetic Resonance Review* (1994–2000)
Fellow of the American Academy of Arts and Sciences (1994)
Irving Langmuir Prize of the American Physical Society (1997)
Charles A. MacDowell Lecturer in Chemical Physics, University of British Columbia (1997)
Distinguished Visiting Professor, Yamagata University (1998)
International Zavoisky Prize, Zavoisky Institute, Russian Academy of Sciences (1998)
Honorary Member, National Magnetic Resonance Society of India (2001)
J.H. Freed Festschrift Issue of *Journal of Physical Chemistry* (July, 2004)
External Advisory Board National High Magnetic Field Laboratory (2006–)
Associate Editor, *Journal of Magnetic Resonance* (2007–2010)
Visiting Scientist, University of Oxford (2007–2013)
E. Bright Wilson Award of the American Chemical Society (2008)
Inaugural Fellow of the International Society of Magnetic Resonance (2008)
President of the International EPR/ESR Society (2008–2010)
Israel Pollak Distinguished Lectureship, Technion, Israel (2009)
Fellow, Royal Society of Chemistry (FRSC) (2009)
Fellow, American Association for the Advancement of Science (2009)
ISMAR Prize, International Society of Magnetic Resonance (2013)
Joel Hildebrand Award of the American Chemical Society (2014)
Voevodsky Prize (2017)
Fellow of the International EPR/ESR Society (2017)

Grad Students

P. Glenn Barkley
 David Bazell
 Jaya Bhatnagar
 Gerald V. Bruno
 Siddarth Chandrasekaran
 Yun-Wei Chiang
 Henry D. Connor
 Antonio da Costa Filho
 Keith A. Earle
 Michael P. Eastman
 Stephen A. Goldman
 Jeff Gorcester
 Pranav Gupta
 Robert G. Kooser
 John C. Lang, Jr.
 Sanghyuk Lee
 Daniel S. Leniart
 Yan Lou
 Glenn L. Millhauser
 Akbar Nayeem
 Carl F. Polnaszek
 Aritro Sinha Roy
 Dipanjan Samanta
 Sunil K. Saxena
 Deniz Sezer
 David J. Schneider
 Leslie J. Schwartz
 Yeon-Kyun Shin
 Andrew K. Smith
 Madhur Srivastava
 Stephen Wagner
 Dajiang Xu
 Stephen A. Zager
 Walter Zeltner
 Gary P. Zientara
 Ziwei Zhang

Postdoctoral Associates, Visiting Scientists, and Collaborators**Postdoctoral Associates**

Jeff P. Barnes
 Nikolas P. Benetis

Nick P. Bigelow
 Aharon Blank
 Wolfgang Buchner
 David E. Budil
 Robert F. Campbell
 Timothée Chauviré
 Laura Ciani
 David A. Cleary
 Richard H. Crepeau (became Sr. Res. Assoc.)
 M. Ramachandra Das
 John S. Denker
 Boris Dzikovski (became Sr. Res. Assoc.)
 Uzi Eliav
 Alberta Ferrarin
 John M. Frank (became Res. Assoc.)
 Barbara Fresch
 Dan Gamliel
 Ming Tao Ge
 Elka R. Georgieva (became Sr. Res. Assoc.)
 Wulf Hofbauer
 Joseph P. Hornak
 James S. Hwang
 Lian-Pin Hwang
 Dan Igner
 Eva Igner
 Burgess R. Johnson
 Leela Kar
 Yoshiya Kera
 Alex Liqi Lai (became Res. Assoc.)
 Keun-Ho Lee
 Laurent P. Levy
 Zhichun Liang (became Sr. Res. Assoc.)
 Wuu-Jyi Lin
 Dmitri Lukoyanov
 W. Bryan Lynch
 Ronald P. Mason
 Eva Meirovitch
 Giorgio Moro
 Alex A. Nevzorov
 Mark Nilges
 Sergei Patchenko
 Baldev Patyal

J. Boiden Pedersen
 Antonino Polimeno
 Shankar B. Rananavare
 Venkata K. S. Rao
 Ayelet Regev
 Diane Richardson
 Gunther Rist
 Tim R. Saarinen
 Yuhei Shimoyama
 Dae Ho Shin
 Masaru Shiotani
 Alex I. Smirnov
 Bryan W. Statt
 Arthur E. Stillman
 Hisao Tanaka
 Dmitri S. Tipikin
 Vitaly Tugarinov
 Galina Ulanova
 Walter V. Volland
 Qi Wang
 William A. Wassam, Jr.
 Bernard Yurke
 Chorong-tao Yu

Senior Visitors

Antonije Dulcic
 Rudolph Durny
 Uwe Ewert
 Vladimir Jidkov
 Josef K. Moscicki
 Boris Naumov
 Yasunori Ohba
 Venkata G. K. M. Pisipati
 Arnold Raitsimring
 Kev M. Salikhov
 Venkata S.S. Sastry
 Musti J. Swamy
 Kashyap V. Vasavada

Senior Research Associates

Peter P. Borbat
 Richard H. Crepeau
 Curt R. Dunnam, engineer

Senior Collaborators

George K. Fraenkel—Ph.D. Advisor
 Christopher A. Alabi
 C. Lindsay Anderson
 Barbara Baird
 Vincenzo Barone
 R. Lynn Belford
 Maina Bennati
 Alexandra Bilwes
 Albert M. Bobst
 Olga Boudker
 H. Alex Brown
 Robert Brittl
 Louis-Claude Brunel
 Robert G. Bryant
 James M. Burlitch
 Samuel Butcher
 Chi-Chang Chu
 Tom G. Clark
 Robert B. Clarkson
 Brian Crane
 Susan Daniel
 John M. Deutch
 James L. Dye
 Dale E. Edmondson
 Peter Edwards
 David Eliezer
 Scott Emr
 Gerald W. Feigenson
 Brett Fors
 Betty Gaffney
 Kevin H. Gardner
 Elizabeth D. Getzoff
 Lila M. Gierasch
 Oleg Grinberg
 Songi Han
 Jeff Harmer
 Ekaterina E. Heldwein
 Brian Hoffman
 David Holowka
 Wayne L. Hubbell
 James S. Hyde
 Ken Kirschenbaum
 Jean-Pierre Korb
 Josef Kovaleski

Danuta Kruk
David M. Lee
Hening Lin
Vsevolod Livshits
Michael G. Malkowski
John A. Marohn
Saba Mattar
Fred Maxfield
Ann McDermott
Hassane S. Mchaourab
Sushil K. Misra

Pier-Luigi Nordio
Chris K. Ober
Jan Pilar
Andrzej Rajca
Benoit Roux
Harold A. Scheraga
Charles P. Scholes
Hal Swartz
Wolfgang Trommer
Francis I. Valiyaveetil
Gary R. Whittaker