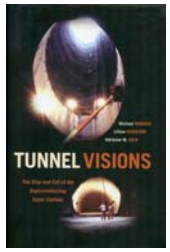
Tunnel Visions

The Rise and Fall of the Superconducting Super Collider



Michael Riordan, Lillian Hoddeson, and Adrienne W. Kolb

U. Chicago Press, 2015. $40.00 (480 pp.). ISBN 978-0-226-29479-7

"Super" is an apt description for the Superconducting Super Collider (SSC), the ill-fated particle accelerator that was well under construction near Dallas, Texas, before it was canceled by the US Congress in 1993. The project was super in size and energy—84 km in circumference, 20 TeV per beam—and it would have been the largest single application of superconducting magnets. If it had been completed, the SSC would now be the most powerful device of its kind, with more than double the energy of CERN's Large Hadron Collider.

However, the SSC got caught in a super mess: small science pitted against big science, pork-barrel politics, conflicting management styles, and changing views of the value of federal investments in science. Ultimately, the downfall of the SSC project was in large part due to rising construction costs, which made the project's budget estimate a moving target: In 1986 it was $3 billion; by 1990 it was $8 billion–$12 billion. The escalating cost became the story in popular and scientific publications during a time when Congress was looking for spending cuts to offset rising federal deficits.

The prospect of siting a multibillion-dollar capital project with a $330 million annual operating budget and more than 1000 permanent staff was a golden prize when the site-selection process began in 1988. The project's sponsoring agency, the Department of Energy, chose Waxahachie—just outside the Dallas suburbs—as the winning site from among 43 bids.

Tunnel Visions: The Rise and Fall of the Superconducting Super Collider, a nearly three-decade writing project, describes the birth and death of the SSC. The authors—Michael Riordan and Lillian Hoddeson, both science historians, and Adrienne Kolb, a retired Fermilab archivist—illuminate the serious problems that led to the 1993 congressional vote to terminate the SSC. Those included several failures in project management and a faulty transition in expertise from the original Central Design Group to the SSC Laboratory that resulted in the inability to attract and retain seasoned accelerator design staff.

The painful history of management pitfalls is laid bare through the authors' extensive interviews and perusals of official governmental records. For example, DOE allowed just three months for contracting teams to pull together a management proposal that included industrial partners. Only the Universities Research Association, which managed Fermilab, was able to respond fast enough. Over time, an increasingly dysfunctional relationship between project managers and DOE administrators responsible for oversight resulted in a cumbersome structure of four poorly communicating levels of management—two from the association and two from DOE.

Riordan, Hoddeson, and Kolb detail the project evolution from conceptual design, to establishment of the SSC Laboratory, to a series of increasingly layered management structures whose intricacies hastened the project's termination. Changes from the original design increased the size and complexity of the magnets, which led to a concurrent doubling of the front-end injector energy. Those changes would have accelerated commissioning and provided more confidence in attaining the full design energy—but they also added $2 billion to the cost. The authors suggest that it would have been better to site the SSC at Fermilab and to copy the CERN model, in which a series of new and larger accelerators could be concatenated using existing infrastructure and existing staff.

The escalating cost of the accelerator was a ripe target for certain members of Congress—for example, the New York delegation, which was already smarting both from losing the SSC site competition and from DOE's 1983 decision to cancel the Isabelle accelerator at Brookhaven National Laboratory. As the SSC's costs rose, other segments of the scientific community targeted it. If the SSC were to be completed and operated for several decades, opponents claimed, there would be less money for federal funding of the rest of science. The materials-science community was particularly vocal.

In the end, the House voted 282–143 to cancel the project. The US high-energy physics community has not yet fully recovered.

I observed the political drama while managing the construction of another superconducting accelerator at the Continuous Electron Beam Accelerator Facility, part of DOE's Thomas Jefferson National Accelerator Facility in Newport News, Virginia. That was a smaller project, but it featured aspects of the SSC project management model and executed them well. It had a strong, hierarchical management scheme, had ties to the national and international research communities, conducted outreach to fields other than nuclear physics that could use the laboratory's infrastructure, and carefully cultivated political support.

The only fault I find with the book is an occasional repetitiveness that tighter editing could have eliminated. Because of my personal ties to the field and to the national lab community, I enjoyed the play-by-play account in *Tunnel Visions*. Others without such connections may dispassionately read this retelling of the birth and death of a megaproject. The SSC has lessons for all who advocate the public funding of science.

H. Frederick Dylla
American Institute of Physics
College Park, Maryland

Thermodynamics, Kinetics, and Microphysics of Clouds

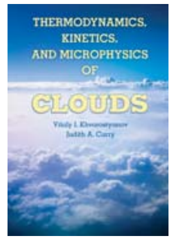
Vitaly I. Khvorostyanov and Judith A. Curry

Cambridge U. Press, 2014. $115.00 (782 pp.). ISBN 978-1-107-01603-3

Thermodynamics, Kinetics, and Microphysics of Clouds, an ambitious text by Vitaly Khvorostyanov and Judith Curry, offers a timely update and extension of the indispensable *Microphysics of Clouds and Precipitation* (Springer, 1996) by Hans Pruppacher and James Klett. The new text is particularly notable for coherently merging a theoretical perspective derived from the Russian cloud-physics tradition with the more accessible Western tradition. At more than 700 pages, it is also comprehensive: Khvorostyanov and Curry have reviewed and synthesized much of the most influential cloud research that has been published through 2013.

The authors in this improbable collaboration come from unique backgrounds and somewhat controversial stations. Khvorostyanov, professor of physics at the Central Aerological Observatory in Moscow, has been a leader at the highest levels of Russian weather modification programs. Curry, a professor in the School of Earth and Atmospheric Sciences at Georgia Tech, has garnered wide attention for her iconoclastic perspectives on climate change and climate modeling.

Despite the polemic aspects of some of the authors' other work, this text is a thoroughly technical compendium, concerned with the detailed physics of clouds. The authors, whose prodigious experience is reflected in more than 400 peer-reviewed publications, have managed to provide a panoramic perspective on cloud physics, yet one that is filled with fine-grained detail.

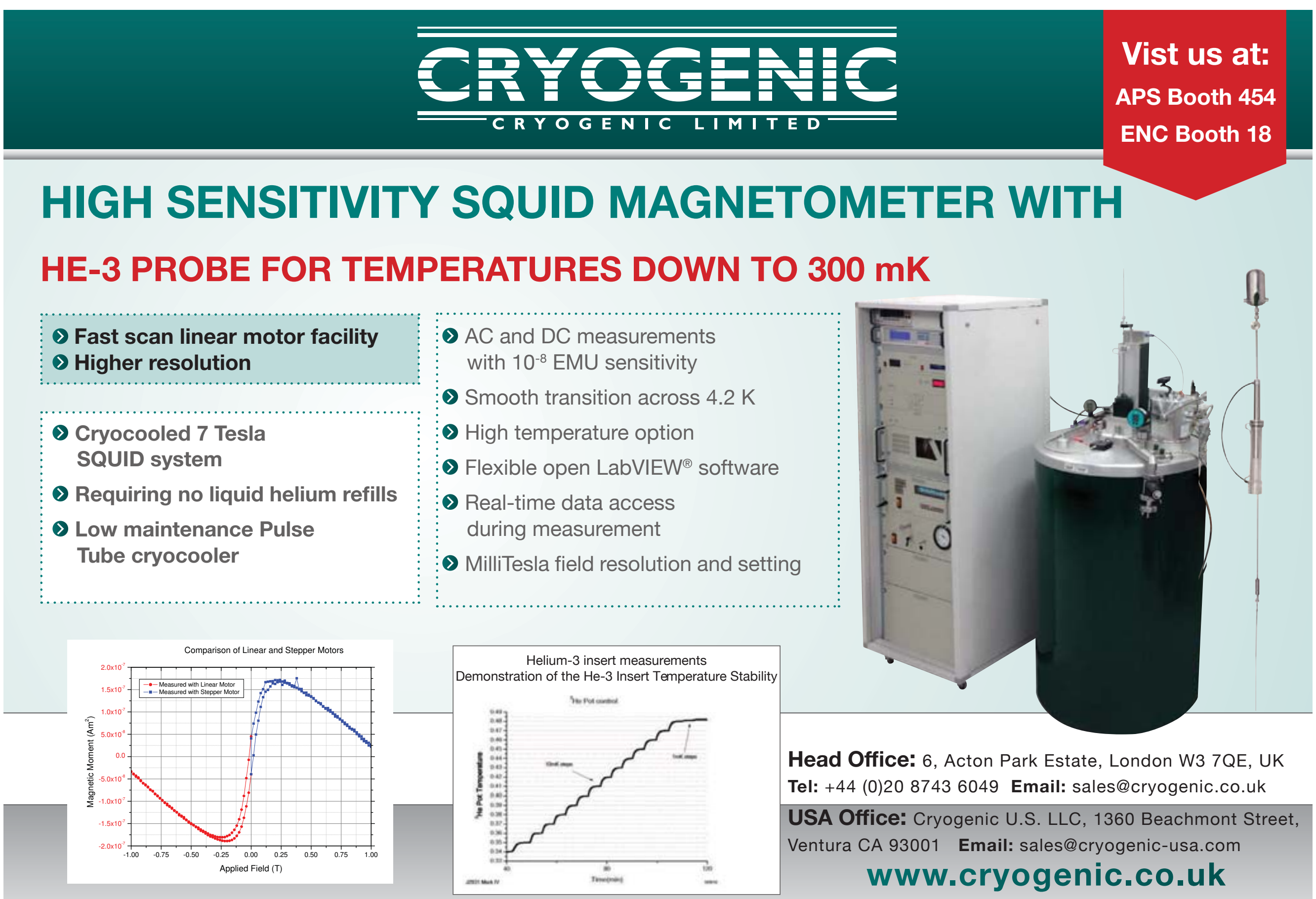


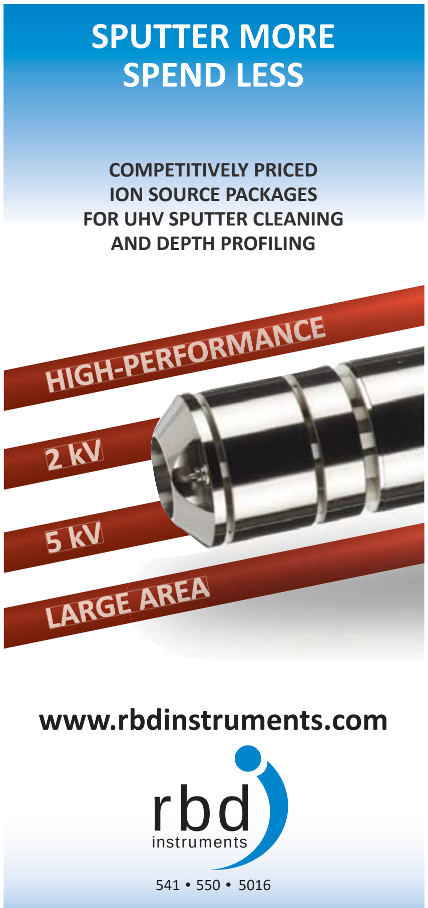
The book begins with a discussion of cloud properties and how clouds are distributed globally. That is followed by definitions of fundamental microphysical cloud properties and a review of particle distributions that give rise to cloud-scale characteristics. Also included in the introductory section are formal mathematical definitions of size spectra, distribution types, and moments as typically used in atmospheric science. Those will be especially valuable to students.

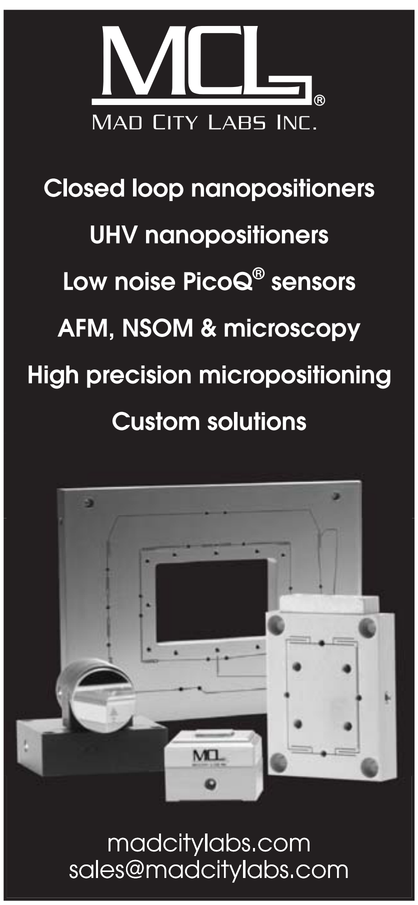
The heart of the text begins with modern treatments of the thermodynamics of water and ice in the atmosphere. It includes essential updates to equations of state for ice and water and new parameterizations of vapor pressure, heat capacity, and latent heat. That thermodynamic foundation is followed by detailed chapters on the diffusional and coalescent growth equations for water, ice, and wet aerosols; more so, the authors include fast algorithmic adaptations of those equations that are suitable for numerical models.

The book also provides comprehensive chapters on both homogeneous and heterogeneous nucleation processes; in those chapters, model-ready adaptations of the nucleation parameterizations are presented in detail. Other topics covered in the remainder of the book include deliquescence and efflorescence of aerosols, particle terminal velocities, and size-spectra broadening by stochastic condensation in turbulent clouds. The text does not attempt to provide a guide to the extensive body of research on cloud electricity or cloud chemistry.

Khvorostyanov and Curry make a great effort to unify theoretical and analytical formulations with empirical results. That approach is a theme throughout the text, and one that sets their book apart from other cloud-physics texts. An exciting and challenging surprise also awaits the reader: Some of the authors' own unpublished works are interwoven through the text. For example, Khvorostyanov and Curry







propose that Bose–Einstein statistics could be adapted to describe atmospheric nucleation processes, and they present a new parameterization of heterogeneous ice nucleation. The inclusion of new, unreviewed work offers the possibility that some aspects of the text can move science forward significantly, but it also demands that readers carefully evaluate the novel aspects of the work, as they have not yet acquired the authoritative sheen of established science.

I highly recommend *Thermodynamics, Kinetics, and Microphysics of Clouds* for atmospheric science professionals and advanced students. Its combination of analytical rigor, up-to-date references, and equations adapted for modeling applications makes it a valuable resource for modelers and experimentalists in cloud physics and climate research. This important work will also challenge readers with its novel approach to the field and provide a fresh perspective that they have likely not encountered.

Nathan Magee
College of New Jersey
Ewing

Fundamentals of Polymer Physics and Molecular Biophysics

Himadri B. Bohidar

Cambridge U. Press, 2015. $110.00 (350 pp.).
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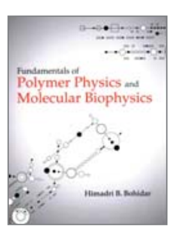
Polymer solutions have captured the interest of researchers across disciplines, from physics and engineering to biology, chemistry, and materials science. Biopolymers, the building blocks of life, appear in such naturally occurring solutions as blood, mucus, and biological cells. Synthetic polymer solutions, found all around us, are essential to a range of industries, from cosmetics, food, and pharmaceuticals to athletics, construction, and defense.

Important and widely varying, those "soft" materials display intriguing non-Newtonian properties—such as viscoelasticity—that are tuned via the lengths, topologies, concentrations, and molecular interactions of the polymers in solution. Experimentalists endeavor to determine intrinsic polymer structures and solution characteristics by measuring diffusion coefficients and other transport properties. However, determining such governing properties as polymer size, shape, and intermolecular interactions from experimentally accessible transport phenomena is a nontrivial task that continues to attract the attention of theorists.

Due to the ubiquity of polymer solutions in biological systems and the mounting demand for new multifunctional materials that mimic those well-adapted biological fluids, an ever-growing number of scientists are working to understand the physics underlying biological soft matter. Researchers in that interdisciplinary endeavor often find themselves straddling the fields of polymer physics and biophysics without a true home in either. Thus, training the field's future researchers is a formidable task requiring courses and texts that are accessible to students from a range of disciplines and that merge critical concepts in polymer physics and molecular biophysics.

Himadri Bohidar's *Fundamentals of Polymer Physics and Molecular Biophysics* is the first text expressly designed for that purpose. Bohidar is chair of the Special Centre for Nanosciences at Jawaharlal Nehru University in New Delhi, India. He developed the text from his lecture notes for a graduate-level physics course, but his intended multidisciplinary audience includes students and experimentalists who have a minimal background in advanced mathematics and molecular biology. The mathematical content and Bohidar's terse style may make some aspects of the text inaccessible to the entire intended audience; however, most chapters conclude with a recap of the main points and some suggested exercises that nicely and accessibly summarize the key concepts of the chapter.

Fundamentals of Polymer Physics and Molecular Biophysics is divided into two sections. The first focuses on the physics of polymer solutions, and the second covers essential molecular biophysics concepts. Bohidar opens with a review of necessary thermodynamics and statistical mechanics and then reviews thermodynamic properties of solutions and phases.



The next several chapters