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# Biography of Irwin Oppenheim

Irwin Oppenheim was born in Boston in 1929 and attended the William Lloyd Garrison School for his first six grades. His family then moved to Brookline, Massachusetts, where he attended the Edward Devotion School and graduated in 1941. Irwin went on to Brookline High School where he graduated in 1945 with the second highest grades in his class and prizes in chemistry and history.

Irwin then moved to Harvard, where he majored in chemistry and physics and graduated in 1949 *summa cum laude*. At Harvard he met his lifelong friend Daniel Kivelson. For graduate school, Irwin went to Caltech to work with Kirkwood. When Kirkwood left to go to Yale after two years, Irwin went with him. An exceptional period in the Yale theory group ensued, with numerous students who were to achieve prominence. Irwin's thesis research involved some of the first usage of the Wigner functions and expansion in powers of Planck's constant to develop quantum corrections to classical distribution functions. These distribution functions were then exploited to deduce thermodynamic properties and transport coefficients. He received his Ph.D. in chemistry in 1956. His thesis committee consisted of Kirkwood, Onsager, and Fuoss. While at Yale Irwin and Kirkwood wrote the classic text "Chemical Thermodynamics".

Irwin started his career as an independent scientist as a subgroup leader at the National Bureau of Standards in 1953. It was during this time that he established long-term collaborations and friendships with N. G. van Kampen, Peter Mazur, Kurt Shuler, and George Weiss. Irwin then moved to Convair, a division of General Dynamics, in San Diego as Chief of the Theoretical Physics Division. Here he worked on understanding turbulence for several years. Irwin moved to MIT in 1961 and has been there ever since. At MIT he established a worldwide reputation in non-equilibrium statistical mechanics. The theory group originally occupied basement offices, and moved into a suite in Building 6 in 1970. Again, an exceptional period of activity and collaboration followed, with the students of Irwin, J. M. Deutch, Robert Silbey, and John Ross, working in close proximity. Theory seminars were held on Wednesday afternoons and were known for the aggressive questioning of the speakers. Christmas party skits by the students satirizing the faculty were not known for restraint.

Irwin Oppenheim has made fundamental contributions to many areas of statistical mechanics, but his work has an overriding theme, namely, the rigorous derivation of dynamical equations for quantities of interest to physical chemists. We are awed by his ability to take a seemingly intractable problem and

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in a short time come up with pages of equations on a legal pad that lead to novel and insightful results.

Irwin's decisive work on the derivation of Langevin equations and master equations describing Brownian motion and other stochastic processes in classical and quantum systems has had a wide impact in many fields. He was one of the earliest workers to recognize both that the density expansion of the transport coefficients was non-analytic and that memory functions that were believed to decay quickly had "long-time tails". The ring kinetic theory explained both of these phenomena by extending the Boltzmann equation to include ring recollisions.

Irwin's work on the derivation and solution of equations describing dynamics in liquids, hydrodynamics, generalized hydrodynamics, light scattering, mode coupling, and long-time tails is considered classic. With the assumption that the densities of dynamically conserved quantities evolve on a unique slow time scale, Irwin produced microscopically derived linear and nonlinear hydrodynamic equations, obtaining a formalism that could be applied to any variable. Application to dielectric fluctuations gave a description of light scattering from molecular liquids. Realizing that products of slow variables are also slow, an early version of "mode coupling" was next obtained, leading to a theory of the long-time tails, and a microscopic derivation of the Stokes–Einstein law at liquid density. Including products of all orders led to the comprehensive multilinear hydrodynamic formalism, which is currently revealing its power in the calculation of multipoint, multitime correlations.

Irwin's pioneering work on properties of nonequilibrium steady states is a true example of his insight coupled with his enormous analytic skills. While originally applied to equilibrium time correlations, the multilinear hydrodynamic theory allows calculation of any average, including time correlations in steady states. A series of papers explored light scattering, spatial correlations, and broken symmetries in steady states, including those far from equilibrium.

Other landmarks include his work on the Brownian motion of many Brownian particles in nonequilibrium baths, on boundary conditions at surfaces, on inelastic properties of granular systems, on nuclear spin relaxation, on counterion condensation in polyelectrolytes, on dynamics of supercooled liquids, and on properties of concentrated suspensions. He has made a significant impact in these fields. In granular systems, for example, Irwin was the first to use statistical mechanics to describe inelasticity and to recognize that the amount of inelasticity was dependent on the relative momentum of the molecule. In concentrated colloidal systems, he was the first to propose a comprehensive theory of the phase transition at a characteristic volume fraction at which diffusion is essentially negligible. The exponents that characterized the phase change were identical to those obtained in deeply supercooled liquids.

Irwin does not seek appointments and awards, but these do come to him. Several examples include his appointment as a Fellow of the American Academy of Arts and Sciences, van der Waals Professorship in Amsterdam, Lorentz Professorship in Leiden, Faraday Society Lecturer, and the American Chemical Society Hilderbrand Award.

Irwin Oppenheim has mentored many graduate and postdoctoral students over the years. We do not use the word "mentored" lightly. Irwin's relationship with his students has always extended far beyond science. Many of us have profited from his wisdom, his unfailing support, his high standards for theoretical research, and his lifetime of friendship.

**Udayan Mohanty**
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*Guest Editors*