Remembering Leo Kadanoff  
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Sabyasachi Bhattacharya

Leo Philip Kadanoff, one of the most important theoretical physicists of our time, whose work has profoundly transformed how we perceive collective phenomena in physics, passed away on 26 October 2015 due to post-surgical complications. In his passing, the world of physics has lost a great mind, an educator, a champion of the importance of science in our lives and society, an extraordinary mentor and a master of his trade with a driving passion to develop a unique culture of collaborative research that often unearthed the profound from the commonplace.

Born in New York City in 1937, Kadanoff received his undergraduate education at Harvard University from where he also received his PhD in 1960, with two dissertations under the guidance of Roy Glauber and Paul Martin. In 1962, he co-authored the classic text *Quantum Statistical Mechanics* with Gordon Baym during his postdoctoral work at the Niels Bohr Institute in Copenhagen.

By 1966, while on the faculty at the University of Illinois, Urbana-Champaign, he produced his monumental work on critical phenomena that led to the profound ideas of universality and scaling. Phase transitions in matter such as solid-to-liquid and liquid-to-vapor, a ferromagnet to a paramagnet or more exotic versions of them, a conventional fluid to a superfluid that has no viscosity or its charge analog – a metal to a superconductor that has no electrical resistance, had been studied extensively over many decades. Paul Ehrenfest categorized them into numbered ‘orders’ depending on which derivative of the free energy showed an abrupt change at the transition point. A first order transition showed such anomalies in the first order derivatives such as entropy and specific volume (inverse of density), while a second order transition showed such behavior in the second derivatives such as specific heat, compressibility, thermal expansion coefficient, and so on. Experiments however, threw up two major surprises for the second order (often called continuous) transitions. First, these second order derivatives actually diverged as...
Kadanoff’s work on scaling provided the key insights that led to the understanding and classification of critical phenomena. The transition was approached instead of being merely discontinuous. Second, disparate groups of systems behaved identically, but differently from other disparate groups in their divergence as seen by distinct sets of critical exponents. Kadanoff’s work on scaling, a mathematical form of recursive coarse-graining, provided the key insights that led to the understanding and classification of critical phenomena. For a detailed technical review of the work, see the article in this issue by Srikanth Shastry (p.875). Two seminal papers appeared in quick succession, the first was a single authored paper on the theoretical and mathematical framework. The second, a multi-authored collaborative review, provided a comprehensive status of both theory and experiment at the time. The pattern of reporting a major discovery followed by a comprehensive contextual view of where the field stood would continue throughout his career.

Kadanoff spent nearly a decade thereafter at Brown University. During this period, he became interested in urban planning by recognizing the similarity in the mathematical formalisms in this field with statistical mechanics of condensed matter systems. This work foretold another of Kadanoff’s lifelong interest: finding mathematical similarity between physical and more complex systems far afield and bringing the power of analogy to gain meaningful insights to a broader problem, in effect, creating generic if not universal classes of problems. His work in this period was judged important enough for the State of Rhode Island of which he was a resident to formally adopt his recommendations.

In 1978, Kadanoff moved to the University of Chicago. It was to be his intellectual home for the rest of his life and many of his extraordinary achievements influencing the course of science in general, and physics in particular, took place here. On an individual level, he continued his work on critical points where the system suddenly changes character. He worked on the onset of chaos in simple dynamical systems, onset of turbulence in fluids, mathematical characterization of instability-driven pattern formation and so on. But he also inspired as well as participated in collaborative research programs, most notably with his colleague Sidney Nagel. Of special note among these enterprises is the by now famous problem of a leaky faucet, the process by which a column of liquid breaks up into droplets.