Invited Speaker 3 (online)

The Lee-Yang Theorem, the Foundation of Discontinuous Phase Transition Theory and its Modern Implication

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Short Abstract:

In the framework of Boltzmann-Gibbs statistical mechanics it had been a puzzle that how different phases could give arise by a sum of smooth functions. There had been a doubt that whether or not partition function based on Boltzmann-Gibbs equilibrium distribution could be used for such purpose. While firmly believed it could, Ehrenfest could not find a suitable scenario. In 1933 Kramers proposed the thermodynamic limit to do the job. But he did not offer a positive and exactly solved example. Onsager provided it in 1944, announced his exact results for the 2d Ising model for continuous phase transition. Then, in series of efforts culminated in 1952 CN Yang and TD Lee showed rigorously that the insights of Ehrenfest and Kramers are correct. It was an elegant demonstration of their insightful intellect powers and ingenious mathematical skills. By now there exist 4 types of fundamental interactions in Nature, but only 3 types of phase transitions: discontinuous, continuous and topological for the bewilderingly complex world. All those show the deep unity and simplicity in physics, and an amazingly beauty. One may notice that the establishments of theories for last two types of phase transitions had already been recognized by Nobel prizes. Even the formulation of the extremely useful mean-field theory was in a sense rewarded with a Nobel prize, to witness the importance of phase transitions in the understanding of our world.

In my talk I will discuss their 1952 results from a physics perspective, with a modern implication. It is a student's learning report during past 40 years on a still active fundamental contribution of masters.

Short bio

Dr. Ping Ao had his BS in physics in 1983 from Peking University, Beijing, China. Same year he went to USA for further study in physics via CUSPEA program initiated by TD Lee. He studied the quantum measurement problem and the macroscopic quantum phenomena at University of Illinois at Urbana-Champaign. Supervised by AJ Leggett he obtained his PhD in physics. He then did his postdoc with DJ Thouless at University of Washington, with a focus on the dynamics of topological defects and their physics implications. Together with Thouless and

others he established the effective equation of motion for vortices in superconductors and superfluid, with under pinning in microscopic theories. He explained the anomalous Hall effect in type II superconductors. During last 20 years he has been working on systems biology and systems medicine. For example, with LE Hood and others he proposed a new theory for cancer genesis and progression to supersede the dominating cancer gene mutation theory. His biological research in evolution motivated him to develop an open, nonlinear stochastic dynamical framework for non-equilibrium processes, providing a unifying theoretical foundation for both biology and physics. His current research covers problems from biology, engineering, medicine, and physics.