北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Seminar

Neo-Gibbsian Statistical Energetics with Applications to Nonequilibrium Cells

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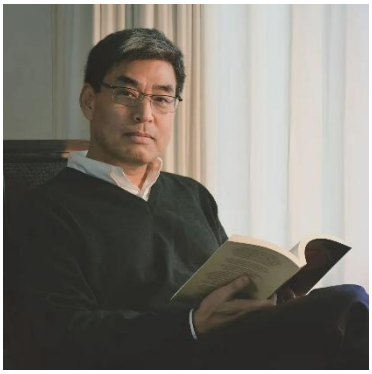

Time: 3:30 pm, Dec.18, 2025 (Thursday)

时间：2025年12月18日（周四）下午3:30

Venue: Room W663, Physics building, Peking University

地点：北京大学物理楼，西663会议室

Abstract

Generalization through novel interpretations of the inner logic of the century-old Gibbs' statistical thermodynamics is presented: i) Identifying kB→0 as classical energetics, one directly derives a pair of thermodynamic variational formulae that dictate all the more familiar 1/T=dS(E)/dE, E=d{F(T)/T}/d(1/T), and S(E)=−dF(T)/dT in equilibrium, which is maintained by a duality symmetry with one-to-one relation between Teq(E)=argminT{E/T−F(T)/T} and Eeq(T)=argminE{E−TS(E)}. ii) In contradistinction, taking derivative of the statistical free energy w.r.t. T, a mesoscopic energetics with fluctuations emerges: This yields two information entropy functions which historically appeared 50 years postdate Gibbs' theory. iii) Combining the above pair of inequalities yields an irreversible thermodynamic potential $\psi(T,E)\equiv\{E-F(T)\}/T-S(E)\geq 0$ for nonequilibrium states. The second law of thermodynamics as a universal principle reflects $\psi\geq 0$ due to a disagreement between E and T as a dual pair. Our theory provides a new energetics of living cells which are nonequilibrium, complex entities under constant T, pressure p and chemical potential μ. ψ provides a ``distance" between statistical data from a large ensemble of cells and a set of intrinsic energetic parameters that encode the information within. This is a joint work with B. Miao and Y.-S. Wu.

About the speaker

Professor Hong Qian is currently a Chaired Professor at Westlake University, Hangzhou. He had been an Olga Jung Wan Endowed Professor of Applied Mathematics at University of Washington, Seattle. He received his B.A. in Astrophysics from Peking University and Ph.D. in Biochemistry from Washington University in St. Louis (with E.L. Elson), and worked as postdoctoral researcher at Univ. of Oregon (with J.A. Schellman) and Caltech (with J.J. Hopfield) on biophysical Chemistry and Mathematical Biology. He was elected a fellow of the American Physical Society in 2010. Professor Qian's current research interest is the probabilistic foundation of statistical equilibrium and nonequilibrium physics and their application to biology, physics, and data science. His recent, coauthored book "Stochastic Chemical Reaction Systems in Biology" was published by Springer in 2021.