Physics
AT QUEENS COLLEGE

Colloquium Notice

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Exploring New Formulations of Classical and Quantum Mechanics

This talk has three parts. The first part is an introduction to Hamilton's two monumental papers from 1834-1835, which introduced the Hamilton-Jacobi equation, Hamilton's equations of motion and the principle of least action [1]. These three formulations of classical mechanics became the three forerunners of quantum mechanics; but ironically none of them is what Hamilton was looking for -- he was looking for a "magical" function, the principal function from which the entire trajectory history can be obtained just by differentiation (no integration) [2]. In the second part of the talk I argue that Hamilton's principal function is almost certainly more magical than even Hamilton realized. Astonishingly, all of the above formulations of classical mechanics can be derived just from assuming that is additive, with no input of physics [3]. The third part of the talk will present a new formulation of quantum mechanics in which the
Hamilton-Jacobi equation is extended to complex-valued trajectories [4], allowing the treatment of classically allowed processes, classically forbidden process and arbitrary time-dependent external fields within a single, coherent framework. The approach is illustrated for barrier tunneling, wavepacket revivals, nonadiabatic dynamics, optical excitation using shaped laser pulses and high harmonic generation with strong field attosecond pulses [5].

1. W. R. Hamilton, On a General Method in Dynamics, Philosophical Transactions, Part 2, p. 247 (1834); ibid., Second Essay on a General Method in Dynamics, Part 1, p. 95 (1835).
2. M. Nakane and C. G. Fraser, The Early History of Hamilton-Jacobi Dynamics 1834-1837, Centaurus 44, 161 (2002); C. Lanczos, The Variational Principles of Mechanics (Oxford, 1949)
3. D. J. Tannor, New derivation of Hamilton's three formulations of classical mechanics (preprint); ibid, Duality of the Principle of Least Action: A New Formulation of Classical Mechanics, arXiv:2109.09094 (2021).
4. Y. Goldfarb, I. Degani and D. J. Tannor, Bohmian mechanics with complex action: A new trajectory based formulation of quantum mechanics, J. Chem. Phys. 125, 231103 (2006); J. Schiff, Y. Goldfarb and D. J. Tannor, Path integral derivations of complex trajectory methods, Phys. Rev. A 83, 012104 (2011); N. Zamstein and D. J. Tannor, Overcoming the root search problem in complex quantum trajectory calculations, J. Chem. Phys. 140, 041105(2014).
5. N. Zamstein and D. J. Tannor, Non-adiabatic molecular dynamics with complex quantum trajectories. I. The adiabatic representation, J. Chem. Phys. 137, 22A518 (2012); W. Koch and D. J. Tannor, Wavepacket revivals via complex trajectory propagation, Chem. Phys. Lett. 683, 306 (2017); W. Koch and D. J. Tannor, A three-step model of high harmonic generation using complex classical trajectories, Annals of Physics, 427, 168288 (2021).

Wednesday
February 14, 2024
Starts at 12:15 PM
Coffee at 12:00 PM
Physics Conference Room, SB B326
This talk is accessible via **Zoom** or use
meeting ID 829 2687 2594 and **passcode 866995** to join