Chirps, Harmonic Oscillators, Heisenberg Uncertainty and Fourier Analysis

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Monday, 10/26, 9:55 am
https://us02web.zoom.us/j/87634916599?pwd=dVFSRERGRnQ0N3pRY1Q4V0hLVzNlQT09
Meeting ID: 876 3491 6599
Passcode: 508472

LECTURE ABSTRACT

Fourier analysis (FA) is central to essentially all types of Engineering, the Physical and Mathematical Sciences, Data and Image Analysis, signals in Biology and Medicine, and the list goes on! It is the mathematical basis of wave propagation of all types. Recently we have explored the fundamental connections between quantum wave phenomena, and especially the Heisenberg Uncertainty Principle (HUP) and the Fourier transform. Features of this theory include: the Gaussian. This “miracle function”: minimizes the variance product of position and its canonical momentum, x , p_x, is the ground state of the quantum harmonic oscillator (HO) and is prominent in statistics, physics, engineering, biology, fluid dynamics, data analysis, etc. It is also unique, being form-invariant under the Fourier Transform (FT).

But there are a vast range of signals and phenomena that are not efficiently described by FA: a host of biological animals’ and insects’ calls, speech, geological signals, medical signals, and most recently gravitational waves. These are known as “chirps” and they vary in a non-linear manner with time and frequency or position and wave number. The questions we addressed are 1) Is the Gaussian a special case of a more general class of functions that are form-invariant under the appropriate generalized FT (GFT)? 2) why are Gaussians so significant for both quantum and classical phenomena? 3) Why is the HUP so fundamentally connected with FA, which is so widespread in both classical and quantum processes? 4) what is special about the ground state in quantum mechanics (QM)? I will explore these questions in this seminar.

SPEAKER BIOSKETCH

Don Kouri (Fellow, American Physical Society) is a mathematical physicist at the UH studying a range of research including quantum scattering, classical scattering, inverse scattering, digital data analysis, developing methods to numerically solve linear and non-linear partial differential equations and since 1991, fundamental consequences of the Heisenberg Uncertainty Principle. He has published approximately 450 peer reviewed journal articles and book chapters, including articles in all 5 sections of the Physical Review, Physical Review Letters, IEEE journals, mathematics journals, Geophysics journals, and in Science. His former students and postdocs hold tenured faculty positions at Cambridge University (UK), UCLA, NYU, Michigan State, Indiana University, University of Georgia as well as chaired positions in the PRC and Taiwan. He is currently mentoring an undergrad student in the ECE Department.

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