APPLIED MATHEMATICS COLLOQUIUM: Vortices and Vortex Rings in Quantum Superfluids: A Quasi-particle Approach

Ricardo Carretero
Professor, Department of Mathematics & Statistics
San Diego State University

Date:
3/19/2021

Time:
3:00 PM – 4:30 PM

Link:
Please contact snsgradstaff@ucmerced.edu for the Zoom link and passcode.

About The Speaker:

Prof. Ricardo Carretero obtained a summa cum laude Physics B.Sc. Degree with honors (Medalla Gabino Barreda) from the Universidad Nacional Autóma de México (UNAM) in 1992. In 1997 he completed a Ph.D. in Applied Mathematics and Computations at the Mathematics Research Centre, Queen Mary University of London under the supervision of David Arrowsmith and Franco Vivaldi. His Ph.D. thesis dealt with front propagation and mode-locking in discrete spatio-temporal dynamical systems. He subsequently joined for two years (1997-1999) the Center for Nonlinear Dynamics and its Application, University College London, for a postdoctoral research fellowship, in collaboration with Jaroslav Stark, on nonlinear time series analysis, reconstruction, and prediction in spatially-extended systems. From 1999 to 2001 he joined the Mathematics department at Simon Fraser University (SFU), Vancouver, under a postdoctoral fellowship from the Pacific Institute for the Mathematical Sciences, Canada, and collaborated with Bob Russell and Keith Promislow on, respectively, adaptive mesh techniques to accurately resolve fine structures and blow-up in partial differential equations and trains of solitary waves (solitons) with applications to fiber optics communications and Bose-Einstein condensation. Since January 2002, he joined the faculty ranks of the Department of Mathematics and Statistics, San Diego State University (SDSU). He was promoted to Associate Professor in 2006 and to Full Professor in 2009. Prof. Carretero co-created and co-directs the Nonlinear Dynamical Systems (NLDS) group and its associated M.S. program in Applied Mathematics with concentration in Dynamical Systems and Chaos. Since 2015 he has been the Associate Chair of the Department of Mathematics and Statistics and the Calculus-II coordinator.

Prof. Carretero's current research focuses on coherent structures in nonlinear media, their formation, existence, stability, complex interactions, and applications. His academic path has given him the opportunity to collaborate and publish more than 125 manuscripts, a couple of books, and several review articles, with a couple hundred collaborators worldwide in a wide spectrum of topics within Applied Mathematics (e.g., medicine, geomorphology, biology, physics, behavioral science, condensed matter, nonlinear optics). His research has been continuously supported since 2005 by external grants from NSF's programs in Mathematics and Physics. According to Google Scholar, he has more than 6,000 citations and an h-index of 40. Prof. Carretero is an avid advocate of the dissemination of science and he frequently delivers engaging talks with interactive demos to middle school, high school, and college students to motivate young students, and in particular minorities, to pursue a career in science. He assisted with the design of an interactive museum exhibit on Chaos and Fractals at Museo Laberinto de las Ciencias y las Artes del Estado de San Luis Potosí, México.

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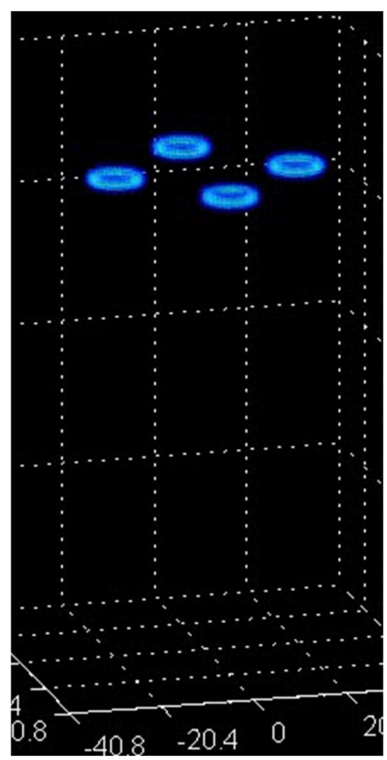
Abstract :

Motivated by recent experiments studying 2D vortex dynamics in Bose-Einstein condensates (BECs), we illustrate that, by considering these vortices as quasi-particles, such systems can be accurately described by reduced models of coupled ordinary differential equations. It is then possible to study in detail the dynamics, stability, and bifurcations of vortex configurations and match the ensuing results to experimental observations.

We will also explore some extensions of the quasi-particle approach for 3D vortex rings which are formed when a vortex line (a "twister") is looped back onto itself creating a close ring that carries vorticity. We first showcase how vortex rings are commonplace in a wide range of fluids. We then focus on the occurrence of vortex rings in BECs and their mutual interactions, collisions, and scattering scenarios. We also briefly discuss an efficient computational implementation for solving the full, original, partial differential equations using GPU accelerated codes in real time!



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