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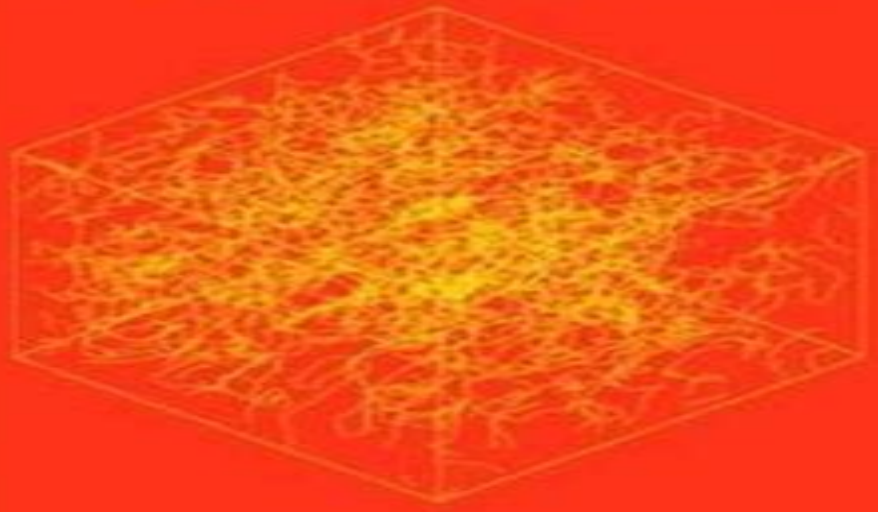

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Quantized Vortex Dynamics And Superfluid Turbulence

Russell J. Donnelly

Quantized Vortex Dynamics And Superfluid Turbulence:

Quantized Vortex Dynamics and Superfluid Turbulence C.F. Barenghi,R.J. Donnelly,W.F. Vinen,2001-08-28 This book springs from the programme Quantized Vortex Dynamics and Sup uid Turbulence held at the Isaac Newton Institute for Mathematical Sciences University of Cambridge in August 2000 What motivated the programme was the recognition that two recent developments have moved the study of qu tized vorticity traditionally carried out within the low temperature physics and condensed matter physics communities into a new era The rst development is the increasing contact with classical uid dynamics and its ideas and methods For example some current experiments with lium II now deal with very classical issues such as the measurement of velocity spectra and turbulence decay rates The evidence from these experiments and many others is that super uid turbulence and classical turbulence share many features The challenge is now to explain these similarities and explore the time scales and length scales over which they hold true The observed classical aspects have also attracted attention to the role played by the ow of the normal uid which was somewhat neglected in the past because of the lack of direct ow visualization Increased computing power is also making it possible to study the coupled motion of super uid vortices and normal uids Another contact with classical physics arises through the interest in the study of super uid vortex connections Reconnections have been studied for some time in the contexts of classical uid dynamics and magneto hydrodynamics MHD and it is useful to learn from the experience acquired in other elds *Quantized Vortex Dynamics and Superfluid Turbulence* C.F. Barenghi,R.J. Donnelly,W.F. Vinen,2014-03-12 This book springs from the programme Quantized Vortex Dynamics and Sup uid Turbulence held at the Isaac Newton Institute for Mathematical Sciences University of Cambridge in August 2000 What motivated the programme was the recognition that two recent developments have moved the study of qu tized vorticity traditionally carried out within the low temperature physics and condensed matter physics communities into a new era The rst development is the increasing contact with classical uid dynamics and its ideas and methods For example some current experiments with lium II now deal with very classical issues such as the measurement of velocity spectra and turbulence decay rates The evidence from these experiments and many others is that super uid turbulence and classical turbulence share many features The challenge is now to explain these similarities and explore the time scales and length scales over which they hold true The observed classical aspects have also attracted attention to the role played by the ow of the normal uid which was somewhat neglected in the past because of the lack of direct ow visualization Increased computing power is also making it possible to study the coupled motion of super uid vortices and normal uids Another contact with classical physics arises through the interest in the study of super uid vortex connections Reconnections have been studied for some time in the contexts of classical uid dynamics and magneto hydrodynamics MHD and it is useful to learn from the experience acquired in other elds Quantized Vortices in Helium II Russell J. Donnelly,1991-03-07 This book discusses the properties of quantized vortex lines in superfluid helium 4 in the light of

research on vortices in modern fluid mechanics and gives the first comprehensive treatment of the problem The author s comprehensive approach will make this book invaluable for students taking advanced undergraduate or graduate courses and for all those involved in research on classical and quantum vortices *Emergent Nonlinear Phenomena in Bose-Einstein Condensates* Panayotis G. Kevrekidis,Dimitri J. Frantzeskakis,Ricardo Carretero-González,2007-12-29 This book written by experts in the fields of atomic physics and nonlinear science covers the important developments in a special aspect of Bose Einstein condensation namely nonlinear phenomena in condensates Topics covered include bright dark gap and multidimensional solitons vortices vortex lattices optical lattices multicomponent condensates mathematical methods rigorous results and the beyond the mean field approach **IUTAM Symposium on Elementary Vortices and Coherent Structures: Significance in Turbulence Dynamics** Shigeo Kida,2006-05-05 Elementary vortices those tubular swirling vortical structures with concentrated vorticity commonly observed in various kinds of turbulent flows play key roles in turbulence dynamics e g enhancement of mixing diffusion and resistance and characterize turbulence statistics e g intermittency Because of their dynamical importance manipulation of elementary vortices is expected to be effective and useful in turbulence control as well as in construction of turbulence modeling The most advanced research works on elementary vortices and related problems were presented and discussed at the IUTAM Symposium in Kyoto Japan 26 28 October 2004 This book contains 40 contributions presented there the subjects of which cover vortex dynamics coherent structures chaotic advection and mixing statistical properties of turbulence rotating and stratified turbulence instability and transition dynamics of thin vortices finite time singularity and superfluid turbulence The book should be useful for readers of graduate and advanced levels in the field of fluid turbulence *Dynamics of Quantised Vortices in Superfluids* Edouard B. Sonin,2016-02-04 A comprehensive overview of the basic principles of vortex dynamics in superfluids this book addresses the problems of vortex dynamics in all three superfluids available in laboratories 4He 3He and BEC of cold atoms alongside discussions of the elasticity of vortices forces on vortices and vortex mass Beginning with a summary of classical hydrodynamics the book guides the reader through examinations of vortex dynamics from large scales to the microscopic scale Topics such as vortex arrays in rotating superfluids bound states in vortex cores and interaction of vortices with quasiparticles are discussed The final chapter of the book considers implications of vortex dynamics to superfluid turbulence using simple scaling and symmetry arguments Written from a unified point of view that avoids complicated mathematical approaches this text is ideal for students and researchers working with vortex dynamics in superfluids superconductors magnetically ordered materials neutron stars and cosmological models **Transport and Turbulence in Quasi-Uniform and Versatile Bose-Einstein Condensates** Gauthier Guillaume,2020-09-26 Advancing the experimental study of superfluids relies on increasingly sophisticated techniques We develop and demonstrate the loading of Bose Einstein condensates BECs into nearly arbitrary trapping potentials with a resolution improved by a factor of seven when compared to

reported systems These advanced control techniques have since been adopted by several cold atoms labs around the world How this BEC system was used to study 2D superfluid dynamics is described In particular negative temperature vortex states in a two dimensional quantum fluid were observed These states were first predicted by Lars Onsager 70 years ago and have significance to 2D turbulence in quantum and classical fluids long range interacting systems and defect dynamics in high energy physics These experiments have established dilute gas BECs as the prototypical system for the experimental study of point vortices and their nonequilibrium dynamics We also developed a new approach to superfluid circuitry based on classical acoustic circuits demonstrating its conceptual and quantitative superiority over previous lumped element models This has established foundational principles of superfluid circuitry that will impact the design of future transport experiments and new generation quantum devices such as atomtronics circuits and superfluid sensors **Non-equilibrium Thermodynamics of Superfluid Helium and Quantum Turbulence** Maria Stella Mongiovì,David Jou,Michele Sciacca,2025-07-23 This book puts together non equilibrium thermodynamics heat transport properties of superfluid He II and thermodynamic and dynamic aspects of quantum turbulence A one fluid extended model of superfluid helium with heat flux as an additional independent variable is presented and compared with the two fluid model to explore how both models complement each other Important features arise in rotating situations and in superfluid turbulence characterized by quantized vortices leading to strong nonlinearities between heat flux and temperature gradient The dynamics of vortex lines and their interaction with heat dynamics a central topic in superfluid turbulence is dealt with by introducing the vortex line density as an independent variable and writing its dynamical equations considering the transitions from laminar to turbulent flows and from diffusive to ballistic regimes Classical and quantum turbulence are compared from a mesoscopic view and from their energy spectra The work also explores some parallelisms of quantum vortex thermodynamics with cosmic string thermodynamics and black hole thermodynamics exhibiting duality connections amongst them It emphasizes didactical views over specialistic details and may be used as an introduction to nonequilibrium thermodynamics of superfluid helium and its heat transport properties second sound nonlocal transport nonlinear connections with quantum turbulence The book is useful to researchers in superfluid helium in heat transport and in thermodynamics of cosmic strings and black holes The diversity and complexity of its several physical equations will be inspiring for researchers in mathematical physics *Vortex Dynamics and Optical Vortices* Hector Perez-De-Tejada,2017-03-01 The contents of the book cover a wide variety of topics related to the analysis of the dynamics of vortices and describe the results of experiments computational modeling and their interpretation The book contains 13 chapters reaching areas of physics in vortex dynamics and optical vortices including vortices in superfluid atomic gases vortex laser beams vortex antivortex in ferromagnetic hybrids and optical vortices illumination in chiral nanostructures Also discussions are presented on particle motion in vortex flows on the simulation of vortex dominated flows on vortices in saturable media on achromatic vortices and on ultraviolet vortices Fractal light vortices

coherent vortex beams together with vortices in electric dipole radiation and spin wave dynamics in magnetic vortices are examined as well **IUTAM Symposium on Computational Physics and New Perspectives in Turbulence** Yukio Kaneda,2007-12-26 This volume contains the proceedings of the IUTAM Symposium on Computational Physics and New Perspectives in Turbulence held at Nagoya University Nagoya Japan in September 2006 With special emphasis given to fundamental aspects of the physics of turbulence coverage includes experimental approaches to fundamental problems in turbulence turbulence modeling and numerical methods and geophysical and astrophysical turbulence *The Defocusing Nonlinear Schr?dinger Equation* Panayotis G. Kevrekidis,Dimitri J. Frantzeskakis,Ricardo Carretero-Gonz?lez,2015-08-04 Bose Einstein condensation is a phase transition in which a fraction of particles of a boson gas condenses into the same quantum state known as the Bose Einstein condensate BEC The aim of this book is to present a wide array of findings in the realm of BECs and on the nonlinear Schr dinger type models that arise therein The Defocusing Nonlinear Schr dinger Equation is a broad study of nonlinear excitations in self defocusing nonlinear media It summarizes state of the art knowledge on the defocusing nonlinear Schr dinger type models in a single volume and contains a wealth of resources including over 800 references to relevant articles and monographs and a meticulous index for ease of navigation **Marine Turbulence** Helmut Z. Baumert,John H. Simpson,Jürgen Sündermann,2005-04-04 This 2005 book gives a comprehensive overview of measurement techniques and theories for marine turbulence and mixing processes It describes the processes which control the mixing of greenhouse gases nutrients trace elements and hazardous substances in our oceans and shelf seas from local to planetary scales These processes buffer climate changes and are centrally important for regional to global ecosystem dynamics The publication also contains source codes of turbulence models and models of the upper ocean mixing layer COHERENS and GOTM and observational data sets of turbulence characteristics or corresponding proxies of waters from all over the world These can be found at www cambridge org 9780521153720 Written by a team of 53 world leading experts it represents a rich source of data and methods for students and scientists in oceanography hydrology limnology and meteorology as well as marine naval and civil engineers *IUTAM Symposium on Reynolds Number Scaling in Turbulent Flow* Alexander J. Smits,2012-12-06 This volume presents selected papers from the IUTAM Symposium on Reynolds Number Scaling in Turbulent Flow convened in Princeton NJ USA September I1 13 2002 The behavior ofturbulence at high Reynolds number is interesting from a fundamental point of view in that most theories of turbulence make very specific predictions in the limit of infinite Reynolds number From a more practical point of view there exist many applications that involve turbulent flow where the Reynolds numbers are extremely large For example large vehicles such as submarines and commercial transports operate at Reynolds 9 numbers based on length ofthe order oft0 and industrial pipe flows cover a 7 very wide range of Reynolds numbers up to 10 Many very important applications of high Reynolds number flow pertain to atmospheric and other geophysical flows where extremely high Reynolds numbers are the rule rather than the exception and the

understanding of climate changes and the prediction of destructive weather effects hinges to some extent on our appreciation ofhigh Reynolds number turbulence behavior The important effects of Reynolds number on turbulence has received a great deal of recent attention The objective of the Symposium was to bring together many of the world s experts in this area to appraise the new experimental results discuss new scaling laws and turbulence models and to enhance our mutual understanding of turbulence Tubes, Sheets and Singularities in Fluid Dynamics K. Bajer,H.K. Moffatt,2006-04-11 Modern experiments and numerical simulations show that the long known coherent structures in turbulence take the form of elongated vortex tubes and vortex sheets The evolution of vortex tubes may result in spiral structures which can be associated with the spectral power laws of turbulence The mutual stretching of skewed vortex tubes when they are close to each other causes rapid growth of vorticity Whether this process may or may not lead to a finite time singularity is one of the famous open problems of fluid dynamics This book contains the proceedings of the NATO ARW and IUTAM Symposium held in Zakopane Poland 2 7 September 2001 The papers presented carefully reviewed by the International Scientific Committee cover various aspects of the dynamics of vortex tubes and sheets and of their analogues in magnetohydrodynamics and in quantum turbulence The book should be a useful reference for all researchers and students of modern fluid dynamics

Probing Two-Dimensional Quantum Fluids with Cavity Optomechanics Yauhen Sachkou,2020-07-17 Superfluid helium is a quantum liquid that exhibits a range of counter intuitive phenomena such as frictionless flow Quantized vortices are a particularly important feature of superfluid helium and all superfluids characterized by a circulation that can only take prescribed integer values However the strong interactions between atoms in superfluid helium prohibit quantitative theory of vortex behaviour Experiments have similarly not been able to observe coherent vortex dynamics This thesis resolves this challenge bringing microphotonic techniques to bear on two dimensional superfluid helium observing coherent vortex dynamics for the first time and achieving this on a silicon chip This represents a major scientific contribution as it opens the door not only to providing a better understanding of this esoteric quantum state of matter but also to building new quantum technologies based upon it and to understanding the dynamics of astrophysical superfluids such as those thought to exist in the core of neutron stars **Quantum Mechanics In Nonlinear Systems** Xiao-feng Pang,2005-04-18 In the history of physics and science quantum mechanics has served as the foundation of modern science This book discusses the properties of microscopic particles in nonlinear systems principles of the nonlinear quantum mechanical theory and its applications in condensed matter polymers and biological systems The book is essentially composed of three parts The first part presents a review of linear quantum mechanics as well as theoretical and experimental fundamentals that establish the nonlinear quantum mechanical theory The theory itself and its essential features are covered in the second part In the final part extensive applications of this theory in physics biology and polymer are introduced The whole volume forms a complete system of nonlinear quantum mechanics The book is intended for researchers graduate students as well as upper level

undergraduates A Journey into Quantization in Astrophysics Florentin Smarandache,Victor Christianto,2013 The present book consists of 17 select scientific papers from ten years of work around 2003 2013 The topic covered here is quantization in Astrophysics We also discuss other topics for instance Pioneer spacecraft anomaly We discuss a number of sub topics for instance the use of Schr dinger equation to describe celestial quantization Our basic proposition here is that the quantization of planetary systems corresponds to quantization of circulation as observed in superfluidity And then we extend it further to the use of complex Ginzburg Landau equation to describe possible nonlinearity of planetary quantization The present book is suitable for young astronomers and astrophysicists as well as for professional astronomers who wish to update their knowledge in the vast topic of quantization in astrophysics This book is also suitable for college students who want to know more about this subject **Nonlinear Dispersive Equations** Christian Klein,Jean-Claude Saut,2022-02-23 Nonlinear Dispersive Equations are partial differential equations that naturally arise in physical settings where dispersion dominates dissipation notably hydrodynamics nonlinear optics plasma physics and Bose Einstein condensates The topic has traditionally been approached in different ways from the perspective of modeling of physical phenomena to that of the theory of partial differential equations or as part of the theory of integrable systems This monograph offers a thorough introduction to the topic uniting the modeling PDE and integrable systems approaches for the first time in book form The presentation focuses on three universal families of physically relevant equations endowed with a completely integrable member the Benjamin Ono Davey Stewartson and Kadomtsev Petviashvili equations These asymptotic models are rigorously derived and qualitative properties such as soliton resolution are studied in detail in both integrable and non integrable models Numerical simulations are presented throughout to illustrate interesting phenomena By presenting and comparing results from different fields the book aims to stimulate scientific interactions and attract new students and researchers to the topic To facilitate this the chapters can be read largely independently of each other and the prerequisites have been limited to introductory courses in PDE theory **Thermodynamics of Fluids Under Flow** David Jou,José Casas-Vázquez,Manuel Criado-Sancho,2010-12-02 This is the second edition of the book Thermodynamics of Fluids under Flow which was published in 2000 and has now been corrected expanded and updated This is a companion book to our other title Extended irreversible thermodynamics D Jou J Casas V zquez and G Lebon Springer 4th edition 2010 and of the textbook Understanding non equilibrium thermodynamics G Lebon D Jou and J Casas V zquez Springer 2008 The present book is more specialized than its counterpart as it focuses its attention on the non equilibrium thermodynamics of flowing fluids incorporating non trivial thermodynamic contributions of the flow going beyond local equilibrium theories i e including the effects of internal variables and of external forcing due to the flow Whereas the book s first edition was much more focused on polymer solutions with brief glimpses into ideal and real gases the present edition covers a much wider variety of systems such as diluted and concentrated polymer solutions polymer blends laminar and turbulent superfluids phonon hydrodynamics and heat transport in nanosystems nuclear

collisions far from equilibrium ideal gases and molecular solutions It also deals with a variety of situations emphasizing the non equilibrium flow contribution temperature and entropy in flowing ideal gases shear induced effects on phase transitions in real gases and on polymer solutions stress induced migration and its application to flow chromatography Taylor dispersion anomalous diffusion in flowing systems the influence of the flow on chemical reactions and polymer degradation The new edition is not only broader in scope but more educational in character and with more emphasis on applications in keeping with our times It provides many examples of how a deeper theoretical understanding may bring new and more efficient applications forging links between theoretical progress and practical aims This updated version expands on the trusted content of its predecessor making it more interesting and useful for a larger audience **Aromaticity** Israel Fernandez,2021-05-16 Evaluating the aromaticity of a molecular system and the influence of this concept on its properties is a crucial step in the development of novel aromatic systems Modern computational methods can provide researchers with a high level of insight into such aromaticity but identifying the most appropriate method for assessing a specific system can prove difficult Aromaticity Modern Computational Methods and Applications reviews the latest state of the art computational methods in this field and discusses their applicability for evaluating the aromaticity of a system In addition to covering aromaticity for typical organic molecules this volume also explores systems possessing transition metals in their structures macrocycles and even transition structures The influence of the aromaticity on the properties of these species including the structure magnetic properties and reactivity is highlighted along with potential applications in fields including materials science and medicinal chemistry Finally the controversial and fuzzy nature of aromaticity as a concept is discussed providing the basis for an updated and more comprehensive definition of this concept Drawing on the knowledge of an international team of experts Aromaticity Modern Computational Methods and Applications is a unique guide for anyone researching studying or applying principles of aromaticity in their work from computational and organic chemists to pharmaceutical and materials scientists Reviews a range of computational methods to assess the aromatic nature of different compounds helping readers select the most useful tool for the system they are studying Presents a complete guide to the key concepts and fundamental principles of aromaticity Provides guidance on identifying which variables should be modified to tune the properties of an aromatic system for different potential applications

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