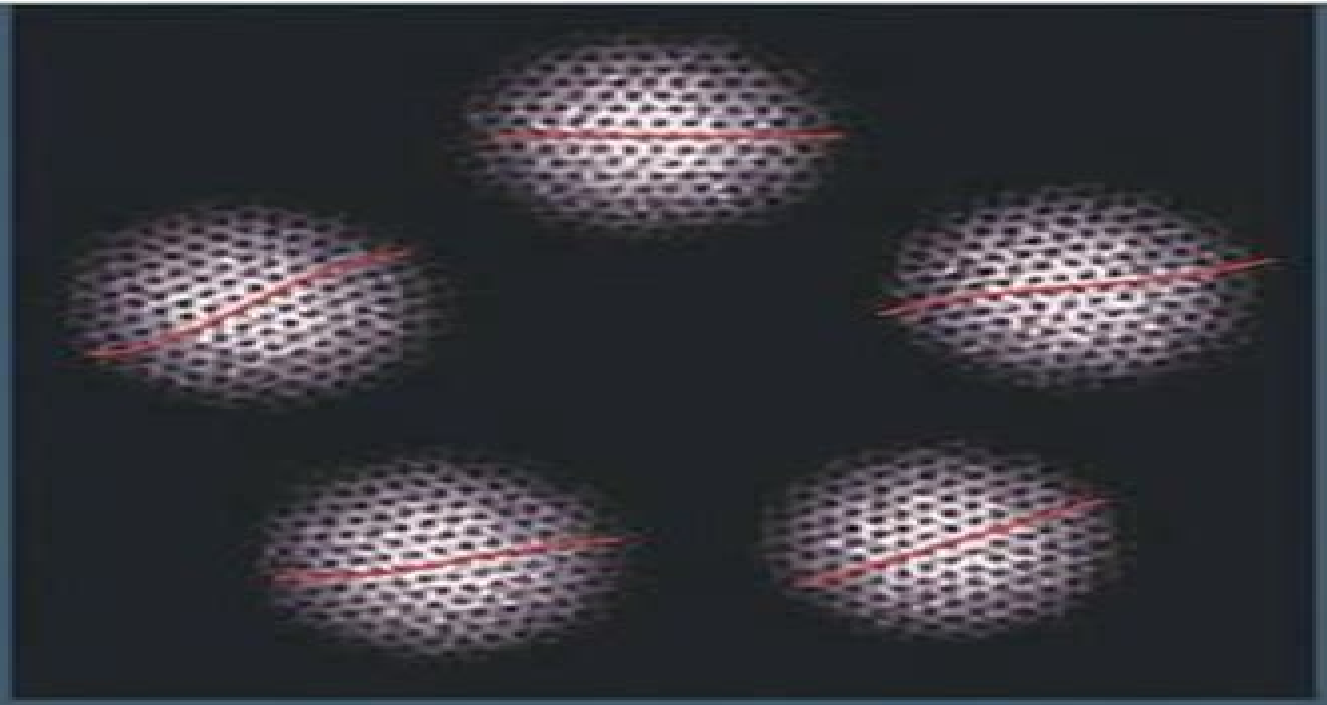
# Dynamics of Quantised Vortices in Superfluids

Edouard B. Sonin



# Dynamics Of Quantised Vortices In Superfluids

Alberto Villois

**Dynamics Of Quantised Vortices In Superfluids:**

*Dynamics of Quantised Vortices in Superfluids* Edouard B. Sonin,1922 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

**Dynamics of Quantised Vortices in Superfluids** Edouard B. Sonin,2016-02-04 This book draws together all the basic principles of vortex dynamics in neutral superfluids in one comprehensive volume 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 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 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

Progress in Low Temperature Physics ,2008-11-05 Progress in Low Temperature Physics Quantum Turbulence presents seven review articles on the recent developments on quantum turbulence Turbulence has been a great mystery in natural

science and technology for more than 500 years since the time of Leonardo da Vinci Recently turbulence in quantum systems at low temperatures has developed into a new research field Quantum turbulence is comprised of quantized vortices realized in superfluid helium and quantum gases of cold atoms Some of the important topics include energy spectra vibrating structures and visualization techniques The understanding of these remarkable systems can have an impact on the general field of turbulence and will be of broad interest to scientists and students in low temperature physics hydrodynamics and engineering Key subjects covered Energy spectra in quantum turbulence Turbulent dynamics in rotating helium superfluids a comparison of 3He B and 4He II Quantum turbulence in superfluid 3He at very low temperatures The use of vibrating structures in the study of quantum turbulence Visualization of quantum turbulence Capillary turbulence on the surface of quantum fluids Quantized vortices in atomic Bose Einstein condensates Crucial information for all experimenters in low temperature physics **Gribov-80 Memorial Volume: Quantum Chromodynamics And Beyond - Proceedings Of The Memorial Workshop Devoted To The 80th Birthday Of V N Gribov** Yuri L Dokshitzer,Peter Levai,Julia Nyiri,2011-04-26 Vladimir Naumovich Gribov was one of the most outstanding theoretical physicists a key figure in the development of modern elementary particle physics His insights into the physics of quantum anomalies and the origin of classical solutions instantons the notion of parton systems and their evolution in soft and hard hadron interactions the first theory of neutrino oscillations and conceptual problems of quantization of non Abelian fields uncovered by him have left a lasting impact on the theoretical physics of the 21st century Gribov 80 the fourth in a series of memorial workshops for V N Gribov was organized on the occasion of his 80th birthday in May 2010 at the Abdus Salam International Centre for Theoretical Physics The workshop paid tribute to Gribov s great achievements and brought close colleagues younger researchers and leading experts together to display the new angles of the Gribov heritage at the new energy frontier opened up by the Large Hadron Collider The book is a collection of the presentations made at the workshop The Physics and Astrophysics of Neutron Stars Luciano Rezzolla,Pierre Pizzochero,David Ian Jones,Nanda Rea,Isaac Vidaña,2019-01-09 This book summarizes the recent progress in the physics and astrophysics of neutron stars and most importantly it identifies and develops effective strategies to explore both theoretically and observationally the many remaining open questions in the field Because of its significance in the solution of many fundamental questions in nuclear physics astrophysics and gravitational physics the study of neutron stars has seen enormous progress over the last years and has been very successful in improving our understanding in these fascinating compact objects The book addresses a wide spectrum of readers from students to senior researchers Thirteen chapters written by internationally renowned experts offer a thorough overview of the various facets of this interdisciplinary science from neutron star formation in supernovae pulsars equations of state super dense matter gravitational wave emission to alternative theories of gravity The book was initiated by the European Cooperation in Science and Technology COST Action MP1304 Exploring fundamental physics with compact stars NewCompStar **Dynamics of Quantized Vortices in**

**Applied Flow in Superfluid 3He-B** Robert Jan de Graaf,2011 **Liquids** ,1989-07 **Dynamics of Quantized Vortices and Electron Bubbles in the Gross-Pitaevskii Model of a Superfluid** Alberto Villois,2018 *Vortices in Unconventional Superconductors and Superfluids* Rudolf Huebener,2002-01-22 Topological defects are generic in continuous media In the relativistic quantum vacuum they are known as cosmic strings in superconductors as quantized flux lines and in superfluids low density atomic Bose Einstein condensates and neutron stars as quantized vortex lines This collection of articles by leading scientists presents a modern treatment of the physics of vortex matter mainly applied to unconventional superconductors and superfluids but with extensions to other areas of physics **Quantum Dynamics of Two Dimensional Superfluid Vortices** Andrew Mark Thompson,1995 **Structure and Dynamics of Vortices in Superfluid Helium-3** Janne Karimäki,2012 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 *Mathematical Reviews* ,1986 **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

*Exotic Properties Of Superfluid Helium 3* Grigori Volovik,1992-03-31 This book discusses the unique properties of superfluid phases of 3He the condensed matter with the outmost broken symmetry which combine in a surprising way the properties of ordered magnets liquid crystals and superfluids The complicated vacuum state of these phases with a large number of fermionic and bosonic quasiparticles and topological objects remains the vacuum in modern quantum field theories Some of the objects and physical phenomena in 3He have strong analogy with the neutrino W bosons weak

interactions gravity chiral anomaly Quantum Hall Effect and fractional statistics As an example of topological objects the quantized vortices in 3He phases are discussed in detail including singular and continuous vortices half quantum vortices broken symmetry in the vortex core and phase transitions between the vortex states with different symmetry and topology

**Quantum Dynamics of Vortices in Two-dimensional Superfluids in the Proximity to Mott Insulators** Lorenz Bartosch,2008

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