



# THE DISCOVERY OF SUPERCONDUCTIVITY

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 ■ Peter Kes - Leiden Institute of Physics, PO Box 9504, 2300 RA Leiden, The Netherlands - [kess@phys.leidenuniv.nl](mailto:kess@phys.leidenuniv.nl) - DOI: 10.1002/epn.2011104

One hundred years ago, on April 8, 1911, Heike Kamerlingh Onnes and his staff at the Leiden cryogenic laboratory were the first to observe superconductivity [1]. In a frozen mercury wire, contained in seven U-shaped capillaries in series (see Fig. 1), electrical resistance suddenly seemed to vanish at 4.16 kelvin [2]. Short-circuit – an apparently obvious explanation – was excluded, but the question exactly what was going on would only receive a satisfactory answer at the fundamental level with the publication of the BCS theory in 1957 [3].

The discovery of superconductivity may have been accidental, but nonetheless the experiment was part of a carefully-considered research programme in Leiden. Studying the behaviour of the electrical resistance of metals (such as gold and platinum) at very low temperatures was interesting from both a practical and a theoretical point of view. Practical, because the fact that metal resistors were dependent on temperature made it possible to use them as (secondary) thermometers – thereby raising the possibility of a welcome addition to

the (primary) gas thermometer which, although accurate, was cumbersome to use and slow in response. Theoretical, because Paul Drude had already applied the kinetic theory of gases to an electron gas in a metal in 1900, and on that basis had deduced the linear decrease in resistance with absolute temperature, while William Thomson (Lord Kelvin) had predicted one year later that at extremely low temperatures, the conducting electron would in fact become 'frozen solid' to the atoms, such that at absolute zero, resistance would become infinite [4].

▲ The Atlas detector of the Large Hadron Collider at CERN, Geneva

# Superconductivity From Discovery To Breakthrough

**Annette Bussmann-Holder, Hugo  
Keller, Antonio Bianconi**



## **Superconductivity From Discovery To Breakthrough:**

**Superconductivity** Charlene W. Billings,1991 Discusses the development of new and different types of materials intended to conduct energy more efficiently and how they may be used      **After the Breakthrough** Helga Nowotny,Ulrike Felt,2002-08-22 Short book on the history and sociology of science surrounding the discovery of high temperature superconductivity      **Physics of Solids** Mr. Rohit Manglik,2024-06-24 Examines solid state physics including crystal structures electronic properties and thermal behavior with applications in materials science      **Superconductivity** The Open University, This 12 hour free course gave an overview of superconductors including their history their properties and potential for both science and industry      **Superconductivity** Kristian Fossheim,Asle Sudboe,2005-09-01 Superconductivity Physics and Applications brings together major developments that have occurred within the field over the past twenty years Taking a truly modern approach to the subject the authors provide an interesting and accessible introduction Brings a fresh approach to the physics of superconductivity based both on the well established and convergent picture for most low Tc superconductors provided by the BCS theory at the microscopic level and London and Ginzburg Landau theories at the phenomenological level as well as on experiences gathered in high Tc research in recent years Includes end of chapter problems and numerous relevant examples Features brief interviews with key researchers in the field A prominent feature of the book is the use of SI units throughout in contrast to many of the current textbooks on the subject which tend to use cgs units and are considered to be outdated      High-Tc Copper Oxide Superconductors and Related Novel Materials Annette Bussmann-Holder,Hugo Keller,Antonio Bianconi,2017-03-24 Authored by many of the world s leading experts on high Tc superconductivity this volume presents a panorama of ongoing research in the field as well as insights into related multifunctional materials The contributions cover many different and complementary aspects of the physics and materials challenges with an emphasis on superconducting materials that have emerged since the discovery of the cuprate superconductors for example pnictides MgB<sub>2</sub> H<sub>2</sub>S and other hydrides Special attention is also paid to interface superconductivity In addition to superconductors the volume also addresses materials related to polar and multifunctional ground states another class of materials that owes its discovery to Prof M ller s ground breaking research on SrTiO<sub>3</sub>

**Superconductivity** Gianfranco Vidali,1993-05-06 A popular account of the discovery of the new high temperature superconducting materials      Semiconductors and Superconductors Ron Legarski,Yash Patel,Zoltan Csernus,2024-09-22 Semiconductors and Superconductors From Invention to Innovation is a comprehensive exploration of the fundamental technologies that power modern electronics energy systems and computing Written by Ron Legarski a leading expert in telecommunications and technology solutions this book delves into the discovery evolution and future applications of semiconductors and superconductors two cornerstones of modern science and engineering The book is designed for a wide audience from professionals in the tech industry and academic researchers to students and general readers interested in

understanding the science and technology that drive today's digital world Semiconductors are the building blocks of every microchip transistor and integrated circuit essential components in everything from smartphones to solar cells Superconductors on the other hand have the potential to revolutionize fields like energy transmission quantum computing and medical imaging by enabling technologies that operate with zero electrical resistance This book covers the key milestones in the development of semiconductors and superconductors starting with the invention of the transistor and the discovery of superconductivity It also dives into the applications of these technologies in industries such as telecommunications computing energy systems and medical technology demonstrating their far reaching impact on society Key topics include The physics of semiconductors and superconductors explained in accessible language The history and evolution of transistors integrated circuits and quantum devices How superconducting materials are used in applications ranging from MRI machines to high speed trains The role of semiconductors in smartphones AI systems and energy efficient power grids Future research directions including the pursuit of room temperature superconductors and wide bandgap semiconductors like SiC and GaN The convergence of AI machine learning and nanotechnology in designing next generation semiconductor and superconductor devices The book also provides a forward looking perspective on how these technologies will shape the future particularly in fields like quantum computing artificial intelligence and renewable energy systems With chapters organized for easy navigation technical glossaries and suggested reading for further exploration Semiconductors and Superconductors From Invention to Innovation is an essential resource for anyone looking to understand the technological forces that are driving the world forward

*Iron-based Superconductors* Nan Lin Wang,Hideo Hosono,Pengcheng Dai,2012-11-19 From fundamental physics point of view iron based superconductors have properties that are more amenable to band structural calculations This book reviews the progress made in this fascinating field With contributions from leading experts the book provides a guide to understanding materials physical properties and superconductivity mechanism aspects and is important for students and beginners to have an overall view of the recent progress in this active field

**Superconductors for a Greener Future** Barrett Williams,ChatGPT,2025-06-17 Superconductors for a Greener Future Revolutionizing Energy and Beyond Dive into the transformative world of superconductors and discover how this groundbreaking technology is paving the way for a greener more sustainable future Superconductors for a Greener Future takes you on a riveting journey through the science and potential of these extraordinary materials unveiling their role in tackling some of the planet's most pressing challenges Begin your exploration with an in depth look at what makes a superconductor truly super as you uncover the intricacies of zero electrical resistance through the lens of quantum mechanics This book guides you from the historical breakthroughs in superconductivity to its cutting edge applications in today's energy systems illustrating a clear path towards a more sustainable future Learn how superconductors are set to revolutionize renewable energy systems enhancing the efficiency of solar power and transforming

wind energy dynamics Dive deep into the future of power transmission with superconductors where you ll explore how they promise to drastically reduce energy loss over vast distances ultimately contributing to a smarter more sustainable grid Uncover the science of cryogenics and its environmental impacts and stay ahead in the race for innovation with insights into high temperature superconductors and novel materials Experience the real world applications powering maglev trains and particle accelerators while also understanding the economic and regulatory challenges that lie ahead Superconductors for a Greener Future highlights the importance of cross sector collaboration global partnerships and community engagement Delve into case studies of successful implementation around the globe and imagine the possibilities of a superconductor driven society Equip yourself with knowledge that not only informs but inspires change Whether you re an energy enthusiast policymaker or sustainability advocate this eBook is your essential guide to understanding and advocating for a new era in energy and sustainability Start your journey towards a brighter more sustainable tomorrow today **Superconductors**

**Evolution** Eleanor Hawking, AI, 2025-01-30 Superconductors Evolution presents a fascinating journey through the revolutionary world of superconductivity from its discovery in 1911 to its current applications in modern technology The book expertly navigates the fundamental principles of zero electrical resistance and perfect diamagnetism demonstrating how these properties have transformed various fields from medical imaging to transportation Through clear explanations and real world examples readers gain insight into how superconductors function at extremely low temperatures and their practical applications in MRI machines magnetic levitation trains and power transmission systems The book s three section structure progressively builds understanding beginning with quantum mechanics principles and Cooper pairs before exploring materials science developments in superconducting compounds The final section bridges theory and practice examining real world applications in power grid optimization and quantum computing Supported by extensive research data from global laboratories the text particularly shines in its analysis of high temperature superconductors and their impact on expanding practical applications beyond research facilities What sets this work apart is its balanced approach to technical content and accessibility making complex physics concepts understandable through practical examples and calculations The book addresses current challenges in the field including the quest for room temperature superconductors while maintaining a focus on verified applications rather than speculative possibilities This comprehensive resource serves both as a theoretical foundation for students and a practical guide for professionals in energy infrastructure and transportation engineering

*Fundamentals of Superconductivity* Vladimir Z. Kresin, Stuart A. Wolf, 2013-06-29 The recent discovery of high temperature superconductivity has resulted in a remarkable growth in the amount of research and the number of researchers working in this exciting field Superconductivity is not a new phenomenon in 1991 it will be 80 years old Even though it was the newer discoveries which motivated us to write this book the book itself is mainly a description of the fundamentals of the phenomenon The book is written for a very broad audience including students engin eers teachers scientists and others who

are interested in learning about this exciting frontier of science We have focused on the qualitative aspects so that the reader can develop a basic understanding of the fundamental physics without getting bogged down in the details Because of this approach our list of references is not comprehensive and it is supplemented with a summary of additional reading consisting of monographs and selected review articles The articles we have referenced were either not reflected in the review articles on monographs or were milestones in the development of the field In addition some of the sections which can be skipped during the first reading have been marked with asterisks Until recently superconductivity was considered to belong to the field of low temperature physics This field was born simultaneously with quantum physics at the beginning of this century Initially these two contemporaneous fields developed independently but they soon became strongly coupled

**Wired for Success** Barrett Williams, ChatGPT, 2025-01-05 Unlock the future with **Wired for Success** a groundbreaking eBook that delves deep into the extraordinary world of superconductors unlocking a reservoir of potential set to redefine industries and economies This exhilarating exploration reveals how mastering the mysteries of zero resistance can lead to unprecedented advancements in technology energy and beyond Embark on a journey through the captivating history and physics of superconductivity Understand the enchantment of quantum mechanics and Cooper pairs and discover why the quest for room temperature superconductors stands at the forefront of scientific innovation From revolutionizing power grids to enhancing transportation and beyond superconductors promise to drive efficiencies and unleash new capabilities across numerous domains Imagine a world where energy storage is efficient and renewable energy integration seamless a world where high speed trains and electric vehicles leverage cutting edge superconductor technology to reach unparalleled speeds and performance **Wired for Success** illustrates how these innovations are not only possible but imminent as superconductors pave the way for the next generation of technological breakthroughs Delve into the economic implications learn about the cost benefit dynamics and the looming disruption in financial markets With insights into investment strategies and new opportunities in emerging markets this book serves as a critical guide for savvy investors and forward thinking policymakers Peek into the realm of computing and healthcare where superconductor technology heralds a new era of quantum computing energy efficient electronics and advanced medical diagnostics Understand how this revolution extends to manufacturing logistics and beyond redefining efficiency and innovation in every sector **Wired for Success** is an indispensable resource for anyone looking to harness the power of superconductors Prepare yourself for the transformations ahead and become part of the movement that will shape the future Immerse in case studies analyze real world applications and be inspired by stories of innovation Embrace this superconductor driven revolution and position yourself for success in the impending age of technological wonder

**Superconductors** Randy Simon, Andrew Smith, 2013-11-11

**Fundamental Elements of Applied Superconductivity in Electrical Engineering** Yinshun Wang, 2013-06-24 Superconducting technology is potentially important as one of the future smart grid technologies It is a combination of superconductor materials electrical

engineering cryogenic insulation cryogenics and cryostats There has been no specific book fully describing this branch of science and technology in electrical engineering However this book includes these areas and is essential for those majoring in applied superconductivity in electrical engineering Recently superconducting technology has made great progress Many universities and companies are involved in applied superconductivity with the support of government Over the next five years departments of electrical engineering in universities and companies will become more involved in this area This book will enable people to directly carry out research on applied superconductivity in electrical engineering is more comprehensive and practical when compared to other advances presents a clear introduction to the application of superconductor in electrical engineering and related fundamental technologies arms readers with the technological aspects of superconductivity required to produce a machine covers power supplying technologies in superconducting electric apparatus is well organized and adaptable for students lecturers researchers and engineers lecture slides suitable for lecturers available on the Wiley Companion Website Fundamental Elements of Applied Superconductivity in Electrical Engineering is ideal for academic researchers graduates and undergraduate students in electrical engineering It is also an excellent reference work for superconducting device researchers and engineers **The New Superconductors** Frank J.

Owens, Charles P. Poole Jr., 2006-04-11 In *The New Superconductors* Frank J Owens and Charles P Poole Jr offer a descriptive non mathematical presentation of the latest superconductors and their properties for the non specialist Highlights of this up to date text include chapters on superfluidity the latest copper oxide types fullerenes and prospects for future research The book also features many examples of commercial applications an extensive glossary that defines superconductivity terms in clear language and a supplementary list of readings for the interested lay reader **Superconductors Unveiled** Barrett

Williams, ChatGPT, 2025-01-15 *Superconductors Unveiled* Unlocking the Mysteries of a Transformative Technology Step into the riveting world of superconductors with *Superconductors Unveiled* a comprehensive guide that takes you on an exhilarating journey from the inception of these extraordinary materials to their groundbreaking applications today This eBook delves deeply into the enigmatic phenomenon of superconductivity unraveling the complex secrets that defy conventional understanding Begin your exploration with *The Mystique of Superconductors* where you ll uncover what exactly makes these materials super and meet the pioneers who revolutionized the field Delve into the realm of quantum mechanics to understand the behavior of electrons Cooper pairs and the marvel that is magnetic levitation Experience a cultural and scientific shift in *The Birth of High Temperature Superconductors* as you journey through the breakthroughs that have redefined the boundaries of physics and chemistry Trace the path of the revolutionary cuprate superconductors with detailed insights into the intricate chemistry crystal lattice structures and the fascinating role of doping Discover the real world applications of these materials in *The Applied Physics of Cuprates* and beyond where cutting edge technologies and future projections are explored See how superconductors are poised to transform energy transmission medical imaging and even

the transportation sector through magnetic levitation In Societal Impacts of Superconducting Technologies examine the ethical and economic considerations that accompany these advancements from costs and equity to environmental impacts The narrative continues with compelling personal stories from researchers driving the field forward Superconductors Unveiled draws connections across diverse disciplines blending chemistry physics and materials science with engineering to paint a complete picture of the impact and potential of these remarkable materials Demystify misconceptions and embrace the wonder of superconductors as you envision the innovation packed future they promise Begin your journey into the supranatural world of superconductors where the boundaries of science are constantly being challenged and the future is being forged today      *Superconductors* A. V. Narlikar,2014-04 Unusual and unconventional features of a large variety of novel superconductors are presented and their technological potential as practical superconductors assessed      **100 Years of Superconductivity** Horst Rogalla,Peter H. Kes,2011-11-11 Even a hundred years after its discovery superconductivity continues to bring us new surprises from superconducting magnets used in MRI to quantum detectors in electronics 100 Years of Superconductivity presents a comprehensive collection of topics on nearly all the subdisciplines of superconductivity Tracing the historical developments in supe      **A Materials Science Guide to Superconductors** Susannah Speller,2022 Superconductors capture the imagination with seemingly magical properties that allow them to carry electricity without losing any energy This book tells how superconductors are designed and engineered on the nanoscale It introduces what materials science is all about and why advanced materials have such importance for technological progress



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