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Experimental low-temperature physics

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Preface

Many university physics departments now offer a short series of lectures on low-temperature physics. Usually these are given as a final-year option, or as part of a course on thermal physics. Low-temperature physics pulls together strands from a number of essential core subjects: thermodynamics and statistical physics, quantum physics and solid-state physics. It also provides an interesting framework in which to illustrate and expand on the theoretical concepts taught in previous years. Applications of low temperatures are becoming widespread in research and industry, and a basic grounding in the subject is considered desirable for all serious students of science and technology.

This textbook fills the need for an uncomplicated introduction to experimental aspects of low-temperature physics, concentrating on the methods used to achieve low temperatures in the laboratory. I have avoided the detailed theoretical treatments found in other books, which are primarily aimed at researchers in the subject. Some basic experimental techniques are covered, but at a level that might be of use to an undergraduate project student or a first-year research student using, rather than researching into, low-temperature techniques. I have included theory only where it is essential to illustrate the point being made and without using mathematics or introducing concepts that the average third-year undergraduate student will not have met before.

In Chapters 2 and 3, I review some of the basic physical properties of matter at low temperatures. Detailed theoretical explanations of the properties are not given, because these may be found in other standard textbooks on thermal and solid-state physics. Instead, I pay particular attention to those properties that are relevant to the material of later chapters. In Chapters 4, 5 and 6 I describe the methods that are used to attain low temperatures in the laboratory, starting from around 300 K and ending at less than a microkelvin. Thermometry goes hand in hand with being able to attain low temperatures. In Chapter 7, I describe the methods, both primary and secondary, used to measure low temperatures. Finally, Chapter 8 contains a few 'hints and tips' for the would-be low-temperature experimenter.

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