The Electrical Properties of Disordered Metals
J.S. Dugdale
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In his book, J.S. Dugdale explains and illuminates the highly successful theory of electrical transport in disordered conductors to interested students and non-experts.

Sophisticated theoretical and experimental developments had made it possible by the 1970s to understand in detail the electrical transport properties of simple, crystalline metals. Also around this time the discovery of how to produce metallic glasses by rapid quenching of alloy melts led to an explosion of investigation into the transport properties of these new highly disordered conductors.

The very short mean free path of electrons in these defect-filled materials meant that the conventional Boltzmann theory was inadequate to account for their unusual and highly material dependent transport properties. Some materials, for example, had a negative temperature coefficient of resistance and negative magnetoresistance at low temperatures. Others had nonmonotonic magnetoresistance at low temperatures.

Then came the discovery that multiple scattering of coherent electrons from defects at low temperature could begin to explain these effects in disordered metals. This simple idea of quantum interference which enhances backscattering has become known as weak localization. Together with later additions and refinements such as spin-orbit coupling and interaction effects, this theory accounts for the low temperature transport in many disordered conductors.

Dugdale provides several chapters that outline the conventional theory of electrical transport in simple metals. These serve as a good background for the later chapters and provide an opportunity to show how the conventional theory fails for highly disordered metals. He includes interesting chapters on the Ziman theory of simple liquid metals, thermopower and Hall effects, magnetoresistance, and the various quench methods of production of metallic glasses. The recent development of promising metallic glasses which can be cooled much slower to form bulk material is not discussed.

The second half of the book begins with a chapter on weak localization. Succeeding chapters build in the effects of spin-orbit scattering and the various interaction effects. The author provides a short, convincing, closing chapter with quantitative comparison of several experiments with the theory. An opportunity is missed however to mention important experiments on mesoscopic disordered metals which added support to the theory.

The book is not intended to be a comprehensive research review. However, the important ideas and experiments in this book are effectively explained in understandable physical terms and backed up with straightforward calculations. It succeeds in describing the potentially daunting theory of transport in disordered conductors in a highly intuitive way that will appeal to beginning graduate or advanced undergraduate students or interested non-experts in physics, materials science, chemistry, or electrical engineering.

Reviewer: *Nathan Israeloff is an assistant professor of physics at Northeastern University. His experimental research interests include transport, noise, and mesoscopic phenomena in model complex materials such as glasses and superconducting networks.*