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This Week's Citation Classic

Carruthers P. Theory of thermal conductivity of solids at low temperatures. *Rev. Mod. Phys* **33**:92-138, 1961. [Bell Telephone Laboratories, Murray Hill, NJ]

This paper treats the theory of lattice thermal conductivity of crystals, with emphasis on low temperatures where lattice defects and other scattering centers have a strong effect on the heat transport. Calculations relate the nature of the scatterers to the observed thermal conductivity. [The *SCI*® indicates that this paper has been cited over 235 times since 1961.]

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"During my second year of graduate study at Cornell University my advisor (Gene Dresselhaus) suggested that I might look into theoretical problems in heat transport by lattice vibrations in insulating crystals. Although a satisfactory quantum theory of the (anharmonic) thermal resistivity had been given as early as 1930 by Peierls,[1] not much was done until the 1950s to investigate the effect of lattice defects and other structures on thermal phenomena. At this time a great deal of new data became available. On the theoretical side, Paul Klemens[2] had made a serious study of defect scattering and Joseph Callaway[3] had proposed an ingenious way of combining the complex effects of the several types of phonon interactions in the mechanism of heat conduction. In this circumstance the subject was ripe for synthesis and clarification.

"Following some initial research of my own I had the good fortune to spend the summer of 1959 with the theory group at the Bell Telephone Laboratories (Murray Hill). In this stimulating environment I was inspired to attempt a synthesis of the new aspects of the field, emphasizing the effect of defects. Since this project involved considerable new research, as well as extensions of previous work, I was soon laboring night and day on the project, with a scientific zeal unique to one's first serious research project. By the end of the summer I had finished a first draft of the manuscript, which was circulated for comments. Over the next few months, back at Cornell, I prepared the final draft. This task was enlivened by conversations with the several young experimentalists then working in this field under the leadership of Robert Sproull. The manuscript, read and accepted by E. Condon, then editor of *Reviews of Modern Physics,* was finally published in January 1961. By this time my principal interest had shifted to high energy physics, although for several years I continued to work on problems in lattice conductivity.

"The paper in question is scarcely a standard review article, which fact probably accounts for its popularity. Besides summarizing known facts in a modern way, it presented numerous new results, making the paper also an original source. Finally it contains many suggestions for future research and possible solutions to the proposed problems. Many of these problems have been taken up and solved by subsequent investigators. Ironically, a paper which solves all problems in a field is unlikely to get many citations."

1. **Peierls R E.** Crystal lattices. General theory. *Quantum theory of solids.* New York: Oxford University Press, 1955. p. 1-26.
2. **Klemens P G**. Thermal conductivity and lattice vibrational modes. (Seitz F & Turnbull O, eds.) *Solid state physics.* New York: Academic Press, 1958. Vol. 7, p. 1-98.
3. **Callaway J.** Model for lattice thermal conductivity at low temperatures. *Phys. Rev.* **113**:1046-51, 1959.