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This Week's Citation Classic

Cowley R A. The lattice dynamics of an anharmonic crystal. *Advan. Phys.* **12**:421-80, 1963. [Crystallographic Lab., Cavendish Lab., Univ. Cambridge, Cambridge, England]

The theory of the physical properties of an anharmonic crystal is discussed using many body techniques. The results are applied to thermodynamic, elastic, dielectric, and scattering properties of crystals. [The ***SCI***® indicates that this paper has been cited over 350 times since 1963.]

R.A. Cowley
Department of Physics
University of Edinburgh
Edinburgh EH9 3JZ
Scotland

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"This paper has been widely referenced because it was a timely review and report of the first quantitative calculations at a time when the field was rapidly advancing. The early 1960s was a period when crystal dynamics advanced very rapidly due largely to the development of neutron inelastic scattering techniques. The shell model had just been developed for ionic crystals and pseudo-potential methods for metals so that for almost the first time quantitative models were available for interatomic forces. Neutron scattering and other experimental techniques had also shown that anharmonic forces were important in explaining some properties of real systems. Theories using conventional perturbation theory had been used to discuss these properties, but the formalism was cumber-some and tedious.

"At about the same time, Green functions, Feynman diagrams, and many body theory were beginning to be applied to problems in solid-state physics. The theory of anharmonic crystals required these techniques to be developed to apply to finite temperature problems. This was accomplished in the early-1960s and they were first extensively applied to anharmonic crystals by Maradudin and collaborators.[1] I learnt about these techniques by attending lectures on nuclear physics given by David Thouless, and was encouraged to apply them to alkali halides by my supervisor William Cochran. In the review article which describes this work, I presented one of the first accounts of the use of many body theory to lattice dynamics and applied the techniques to obtain detailed numerical calculations of many properties of alkali halides. I believe the quantitative success of the calculations encouraged others in the field to make the effort to understand the new techniques.

"Unfortunately, the first calculations contained a numerical error and so they were redone correctly and more carefully in two papers[2,3] by Roger Cowley (no family relation) and myself. The same theory formed the basis of less successful calculations on semiconductors with Gerald Dolling,[4] alkali metals with Bill Buyers,[5] and structural phase transistors with Alastair Bruce."[6]

1. **Maradudin A A & Fein A E.** Scattering of neutrons by an anharmonic crystal. *Phys. Rev.* **128**:2589-608, 1962.
2. **Cowley E R & Cowley R A.** Anhannonic interactions in alkali halides. I. *Proc. Roy. Soc. A* **289**:259-80, 1965.
3 ....., Anharmonic interactions in alkali halides. II. *Proc. Roy. Soc. A* **292**:209-23, 1966.
4. **Dolling G & Cowley R A.** The thermodynamics and optical properties of germanium, silicon, diamond and gallium arsenide. *Proc. Phys. Soc.* **88**:463-94, 1966.
5. **Buyers W J & Cowley R A.** Crystal dynamics of potassium. II. Anharmonic effects. *Phys. Rev.* **180**:755-66, 1969.
6. **Bruce A D & Cowley R A.** Lattice dynamics of strontium titanate. *J. Phys. C-Solid State Phys.* **6**:2422-40, 1973.