

CONTENTS

Chapter 1	Basic elements of the theory of lattice dynamics	11
1.1.	The adiabatic approximation.	11
1.2.	Force constants and their properties	15
1.3.	Equations of motion, their solution and phonons	20
1.4.	Thermodynamic properties and frequency spectrum	32
1.5.	Lattice vibrations in ionic crystals	47
1.6.	Microscopic theory of lattice dynamics	59
1.6.1.	Microscopic theory versus phenomenological approaches	59
1.6.2.	Dielectric matrix and lattice dynamics	62
1.6.3.	Effective charge neutrality condition, acoustic modes and dynamical matrix	69
1.6.4.	Electron response in Wannier representation	73
Chapter 2	Lattice dynamics of crystals with compositional disorder	78
2.1.	General features of disordered systems	78
2.1.1.	Introduction	78
2.1.2.	Numerical determination of frequency spectra and eigenvectors	80
2.1.3.	Green functions and multiple scattering theory in lattice dynamics	85
2.2.	Localized and resonant modes in systems with low defect concentrations	98
2.2.1.	The isolated defect approximation	98
2.2.2.	The mass defect approximation	100
2.2.3.	Description of defect vibrations by an Einstein oscillator	109
2.2.4.	Small finite defect concentrations	115
2.3.	Lattice vibrations in mixed crystals and alloys	118
2.3.1.	Experimental findings.	118
2.3.2.	The virtual crystal approximation and the random element isodisplacement model	123
2.3.3.	Disorder activated modes in one-phonon infrared and Raman spectra	129

2.3.4.	The average t -matrix approximation and the coherent-potential approximation	135
2.3.5.	Cluster approximations	147
Chapter 3 Vibrational properties of systems with structural disorder		155
3.1.	Localized vibrational states	155
3.1.1.	The spatial extent of modes in one-dimensional systems	155
3.1.2.	Localization in the Anderson model	161
3.1.3.	Localization of vibrational states in three-dimensional systems	167
3.2.	Plane-wave-like excitations	171
3.2.1.	Experimental and numerical results	171
3.2.2.	Investigation of dispersion and damping by analytical methods	178
3.3.	Vibrational spectra of noncrystalline solids.	189
3.3.1.	Computer results	189
3.3.2.	The cluster-Bethe lattice method	195
Chapter 4 Anharmonic crystals and structural phase transitions		204
4.1.	Weakly anharmonic crystals	204
4.1.1.	Perturbation theory of anharmonic crystals	204
4.1.2.	Second sound and diffusive heat conduction	216
4.2.	Strongly anharmonic crystals in the self-consistent harmonic approximation	223
4.3.	Lattice solitons.	233
4.3.1.	Some general features of solitons	233
4.3.2.	The Toda lattice	237
4.3.3.	Solitons and phonons in a double-well potential model for structural phase transitions	245
4.4.	Electron-phonon driven lattice instabilities, charge density wave excitations and incommensurate structures	257
4.4.1.	Mean field theory of the Peierls instability in one-dimensional metals and charge density wave excitations	257
4.4.2.	Phenomenological theory of order parameter fluctuations in a Peierls system	267
4.4.3.	Statics and dynamics of incommensurate systems near the 'lock-in' transition	270
Appendix 1 Crystal symmetry and the dynamical matrix		280
A1.1.	Crystal symmetry and groups	280
A1.2.	Symmetry of the dynamical matrix and the multiplier representation	281

A1.3.	Classification of the normal modes and block diagonalization of the dynamical matrix	283
Appendix 2	Linear response of the electrons in a crystal to an electromagnetic field	287
Appendix 3	Experimental quantities	297
A3.1.	Interaction of phonons with infrared radiation	297
A3.2.	Raman scattering by phonons	300
A3.3.	Interaction of phonons with thermal neutrons	305
A3.4.	Lattice thermal conductivity	310
References	313
References added in proof	321
Index	324