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«ENRICO FERMI»

COURSE LXXXIX

edited by F. BASSANI, F. FUMI
and M. P. TOSI
Directors of the Course

VARENNA ON LAKE COMO
VILLA MONASTERO
28 June - 16 July 1983

Highlights of Condensed-Matter Theory

ITALIAN PHYSICAL SOCIETY

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a cura di F. BASSANI, F. FUMI

e M. P. TOSI

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1985

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Preface.

This volume originates from the lectures delivered at the LXXXIX Course of the Enrico Fermi School, which was held in Varenna from 28 June to 15 July 1983. The purpose of the Course was to review leading areas in the theory of condensed matter, singling out those aspects which are of preminent current interest. The field is very broad and no attempt at complete coverage was made. The lecturers, who are among the people who have mostly contributed to each individual topic and also to the field as a whole, have agreed to prepare texts of their lectures for final publication.

The result which is now appearing in this volume is an overview of the present status of the physics of condensed matter. It is grouped under five general titles covering i) electronic structure of solids, ii) optical and transport properties, iii) defects and surfaces, iv) liquids and noncrystalline materials, and v) co-operative phenomena, phase transitions and instabilities. The volume should be useful to graduate students at the beginning of their career and also to advanced research professionals. In addition to up-to-date reviews of frontier topics in what may be his specific field of endeavour, the reader will find added stimulus to broaden his limits of competence and to acquire a taste for new problems in related fields, under the guidance of leading authorities.

The foundations of the theory of the electronic structure of solids are presented by W. KOHN in his lecture on the density functional formalism, the applications being reviewed in some detail by M. L. COHEN for nonmetals and by O. K. ANDERSEN for metals. J. C. PHILLIPS next discusses universal aspects of chemical bonding in condensed matter, while new aspects introduced by superlattices are highlighted by M. ALTARELLI.

Optical spectroscopy provides very precise tools for the study of excited electronic states as described by L. HEDIN. The development of lasers, with the possibility of nonlinear optical effects, has opened up new perspectives in this field. In this connection S. RODRIGUEZ and A. QUATTROPANI review nonlinear scattering of light (Brillouin and Raman) and two-photon absorption processes with their applications. R. PEIERLS has revived the fundamental problem of the definition of momentum and pseudomomentum of light and sound in condensed matter.

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Aspects of transport properties in quasi-one-dimensional materials are examined by J. BARDEEN and L. PIETRONERO, while J. R. SCHRIEFFER reviews the topic of solitons and fractional charges in these materials. The newly discovered phenomenon of the fractional quantized Hall effect is presented by E. TOSATTI.

M. SCHLÜTER, J. D. DOW, C. CALANDRA and A. C. LEVI review next achievements of considerable importance in the understanding of impurity and defect states and of surface states and structures.

Many-body effects in quantum fluids are considered by D. PINES and A. W. OVERHAUSER, with emphasis on elementary excitations in liquid helium and in the electron gas and on charge and spin density waves, respectively. Related to these is the area of highly excited semiconductors with their electron-hole liquid phase described by L. V. KELDYSH. Classical liquids, with special emphasis on the structure of ionic liquids and electrolyte solutions, are covered by N. H. MARCH, while J. C. PHILLIPS reviews network glasses.

The last part of the book opens with a discussion of vibrational states and their interaction with electronic states. The behaviour of strongly coupled electron-phonon systems is particularly emphasized by P. W. ANDERSON, and the self-trapping of excited electrons with associated lattice deformation and symmetry breaking by Y. TOYOZAWA.

T. M. RICE and C. DI CASTRO discuss next the role of disorder localization and of electron-electron interactions. Phase transitions appear also through a discussion of scaling in dilute systems by R. B. STINCHCOMBE, other topics in this area being presented by M. RASETTI and A. CONIGLIO. Finally, the problem of symmetry-breaking instabilities and of the transition to chaotic behaviour could not be ignored. H. HAKEN and L. A. LUGIATO discuss examples in various domains of condensed matter, from Gunn oscillations to laser behaviour and optical bistability.

We hope that the reader will find the same enjoyment in this book as we and the other participants in the School had in attending the lectures in Varenna.

F. BASSANI
F. FUMI
M. TOSI

HIGHLIGHTS OF CONDENSED-MATTER THEORY

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INDICE

F. BASSANI, F. FUMI and M. TOSI – Preface . . . . . Pag. XVII

W. KOHN – Density functional theory: fundamentals and applications.

1. Introduction . . . . . » 1
2. Basic density functional theory . . . . . » 1
   2·1. Historical and heuristic introduction . . . . . » 1
      2·1.1. The Thomas-Fermi model . . . . . » 2
      2·1.2. The Hartree model . . . . . » 3
   2·2. The lemma of Hohenberg and Kohn . . . . . » 4
      2·2.1. Lemma . . . . . » 4
      2·2.2. Proof . . . . . » 4
   2·3. The energy functional $E_v[n(r)]$ . . . . . » 6
   2·4. Exact self-consistent single-particle equations. . . . . » 7
3. Approximations and illustrative applications . . . . . » 9
   3·1. The local density approximation (LDA) . . . . . » 9
   3·2. Illustrative application of the local density approximation » 10
      3·2.1. Atoms . . . . . » 10
      3·2.2. Molecules . . . . . » 11
      3·2.3. Bulk solids . . . . . » 11
      3·2.4. Other systems . . . . . » 11
   3·3. Density gradient corrections . . . . . » 11
   3·4. Other improvements over the local density approximation » 13

APPENDIX. – v-representability . . . . . » 13

MARVIN L. COHEN – Applications of the Fermi atomic pseudopotential to the electronic structure of nonmetals.

1. Introduction . . . . . » 16
2. Bulk properties. . . . . » 18
   2·1. Empirical pseudopotentials . . . . . » 18
   2·2. *Ab initio* pseudopotentials . . . . . » 26

此为试读,需要完整PDF请访问: www.ertongbook.com

3. Surfaces and interfaces . . . . . pag. 35
3·1. Self-consistent pseudopotentials . . . . . » 35
3·2. Surfaces . . . . . » 37
3·3. Schottky barriers . . . . . » 47
3·4. Heterojunctions . . . . . » 51
4. Conclusions and future . . . . . » 55

O. K. ANDERSEN, O. JEPSEN and D. GLÖTZEL – Canonical description of the band structures of metals.

1. Introduction . . . . . » 59
2. Linear methods . . . . . » 60
3. Atomic-sphere approximation (ASA) . . . . . » 65
3·1. Phi and phi-dots . . . . . » 66
3·2. Hamiltonian and overlap matrices. . . . . » 68
3·3. Transformation between orbital sets . . . . . » 70
3·4. ASA density and total energy . . . . . » 71
4. Muffin-tin orbitals . . . . . » 73
4·1. Multipole fields and screening . . . . . » 73
4·2. LMTO Hamiltonians . . . . . » 80
4·3. Potential parameters . . . . . » 82
4·4. Transformation to the nearly orthogonal set of LMTOs from the canonical most localized set . . . . . » 85
4·5. Exact tail cancellation, the screened KKR-ASA equations and the picture of Wigner and Seitz . . . . . » 88
4·6. From the KKR-ASA equation to the LMTO-ASA Hamiltonian . . . . . » 90
4·7. Accurate expressions for the wave function . . . . . » 93
4·8. Exact overlap matrix and the combined-correction term » 94
4·9. Convergence in R and l . . . . . » 97
4·10. Moving the atoms . . . . . » 99
4·11. Blowing-up . . . . . » 101
4·12. Folding-down . . . . . » 101
4·13. Ghost bands. . . . . » 110
4·14. Comparison to the traditional LMTO-ASA and ASW methods . . . . . » 111
5. Energy bands of elemental metals . . . . . » 112
5·1. Canonical tight-binding bands. . . . . » 119
5·2. Bare canonical bands . . . . . » 123
5·3. Potential parameters and trends . . . . . » 128
6. Ground-state properties of elemental metals. . . . . » 137
6·1. Cohesive properties. . . . . » 137
6·2. Magnetic properties . . . . . » 152
7. Electronic-structure calculations for metallic compounds . . » 162
8. Surface calculations. . . . . » 167
9. Conclusion and outlook . . . . . » 170

J. C. PHILLIPS – Universal aspects of chemical bonding . . . pag. 177

A. W. OVERHAUSER – Broken symmetry in simple metals.

1. Introduction . . . . . » 194
2. The evidence . . . . . » 195
3. Theory of charge density waves . . . . . » 201
   3·1. SDW-CDW instability theorem . . . . . » 202
   3·2. The correlation energy correction . . . . . » 204
   3·3. Analogy with uniform deformations . . . . . » 206
   3·4. Implications for many-electron theory . . . . . » 207
4. CDW phenomena . . . . . » 210
   4·1. Optical anomalies . . . . . » 210
   4·2. Conduction electron spin resonance splitting . . . . . » 212
   4·3. Nonreproducibility, a consequence of Q domains . . . » 212
   4·4. Linear magnetoresistance . . . . . » 212
   4·5. Hall coefficient discrepancy . . . . . » 213
   4·6. Induced-torque anisotropy . . . . . » 213
   4·7. The oil drop effect . . . . . » 215
   4·8. Residual-resistance anisotropy . . . . . » 215
   4·9. Temperature dependence of resistivity near 1 K . . . » 216
   4·10. Temperature dependence of the surface impedance . . » 217
   4·11. Deviations from Matthiessen's rule . . . . . » 218
   4·12. Doppler-shifted cyclotron resonance . . . . . » 218
   4·13. Phason anomaly in point contact spectroscopy . . . . » 219
5. Conclusion . . . . . » 221

M. ALTARELLI and A. FASOLINO – Band structure and Landau levels of semiconductor superlattices in the envelope function approximation.

1. Introduction . . . . . » 225
2. Symmetry analysis of one-electron states . . . . . » 227
3. Method of calculation and results for InAs-GaSb . . . . . » 228
4. Landau levels of superlattices . . . . . » 233

R. PEIERLS – Momentum and pseudomomentum of light and sound.

1. Introduction . . . . . » 237
2. Definition of pseudomomentum . . . . . » 238
3. Pseudomomentum of flow . . . . . » 240
4. Immersed object . . . . . » 243
5. Electromagnetic field . . . . . » 244
6. Polarizable medium . . . . . » 245

7. Light pulse . . . . . pag. 247
8. Momentum of sound . . . . . » 248
9. Effect of dispersion and nonlinearity . . . . . » 250
10. Momentum of light . . . . . » 252

L. HEDIN – Lifetime effects in condensed-matter spectroscopy.

1. Introduction . . . . . » 256
2. A simple model for lifetime effects—one discrete state coupled to a continuum . . . . . » 259
3. Formal scattering theoretic solution of the lifetime problem » 266
4. Decay operators and the decay process . . . . . » 271
5. Qualitative discussion of the transition probability . . . . » 275
6. Time-dependent formulation . . . . . » 277
7. Effects of incomplete phonon relaxation in emission spectra » 281

L. HEDIN – Spectra involving quasi-localized valence electrons.

1. Qualitative discussion . . . . . » 288
2. Auger spectra from transition metals . . . . . » 290
3. Resonance effects in valence electron spectra at threshold for core electron excitation . . . . . » 293

J. R. SCHRIEFFER – Solitons and fractional charge in quasi-one-dimensional conductors.

PART I. – Conjugated linear polymers . . . . . » 300

I.1. $(CH)_x$: experimental facts . . . . . » 302
I.2. The coupled electron-phonon system in one dimension . » 307
I.3. Soliton excitations . . . . . » 310
I.4. Continuum limit . . . . . » 313
I.5. Soliton quantum numbers . . . . . » 315
I.6. Polaron excitations . . . . . » 318

PART II. – Dynamical properties . . . . . » 319

II.1. Phonons and soliton vibrations; infra-red absorption . . » 319
II.2. Electronic excitations: optical absorption . . . . . » 321
II.3. Molecular dynamics in the adiabatic approximation . . » 322
II.3'1. Spontaneous generation of a soliton . . . . . » 323
II.3'2. Photoproduction of $S\bar{S}$ via eh pair excitation . . » 324
II.3'3. Polaron formation . . . . . » 326
II.4. Charge branching ratio of photoproduced $S\bar{S}$ pairs . . . » 326
II.5. Quantum nuclear dynamics . . . . . » 327

PART III. – Fractionally charged solitons . . . . . pag. 331
III.1. $m = 3$ case or 1/3 filled band . . . . . » 332
III.2. Quantum sharpness of fractional charge . . . . . » 336

PART IV. – Residual interactions . . . . . » 338
IV.1. Soliton-phonon interactions . . . . . » 338
IV.2. Metal-insulator transition . . . . . » 339
IV.3. Three-dimensional effects . . . . . » 342
IV.3·1. Interchain electron hopping . . . . . » 342
IV.3·2. Interchain electron-electron coupling . . . . . » 343
IV.4. Intrachain electron-electron interactions . . . . . » 344
IV.5. Conclusion . . . . . » 345

J. BARDEEN – Charge transport by charge density waves in linear-chain conductors.

1. Introduction . . . . . » 349
2. Peierls-Fröhlich model of conduction by moving CDWs . . » 352
3. Solutions of the equation of motion . . . . . » 356
4. Comparison of classical, quantum theories of depinning . . » 359
5. Photon-assisted tunneling . . . . . » 361
6. Conclusions and acknowledgments . . . . . » 366

S. RODRIGUEZ and A. K. RAMDAS – Inelastic light scattering in crystals.

1. Introduction . . . . . » 369
2. Theory of light scattering . . . . . » 370
2·1. Scattering cross-section . . . . . » 370
2·2. The dipole approximation. The Raman tensor and the selection rules . . . . . » 372
3. Phonons in perfect crystals . . . . . » 376
4. Phonons in mixed crystals . . . . . » 397
5. Magnetic excitations . . . . . » 405
5·1. Paramagnetic phase . . . . . » 405
5·2. Magnetically ordered phase . . . . . » 411
6. Concluding remarks . . . . . » 418

A. QUATTROPANI – Nonlinear optical properties: two-photon transitions in atoms and solids.

1. Introduction . . . . . » 421
2. General theory . . . . . » 422
3. The two-photon transition rate . . . . . » 424

4. Two-photon transitions in atomic hydrogen . . . . . pag. 426
5. Sum rules and approximate calculations . . . . . » 430
6. Nonlocal potentials . . . . . » 434
7. Two-photon transitions to exciton states . . . . . » 437

L. PIETRONERO – Nonlinear dynamics of pinned charge density waves.

1. Introduction . . . . . » 442
2. Hamiltonian for phase dynamics . . . . . » 443
3. Current-field relation . . . . . » 445
4. Pinned-unpinned phase diagram . . . . . » 449

E. TOSATTI, M. PARRINELLO and C. D. CHEN – The fractional quantized two-dimensional Hall effect.

1. The phenomena . . . . . » 453
2. The Hamiltonian . . . . . » 454
3. Some simple known facts about H_0 . . . . . » 456
   3·1. Exact solution at $\nu = 1$ . . . . . » 456
   3·2. Variational lower bound for all $\nu \leqslant 1$. . . . . » 456
   3·3. Electron-hole symmetry . . . . . » 457
4. Hartree-Fock « charge density waves » (CDW) . . . . . » 457
5. Magnetic Wigner commensurate superlattice. . . . . » 458
6. Superlattices in k-space . . . . . » 459
7. Correlated Jastrow functions. . . . . » 459
8. Numerical approaches. . . . . » 460
9. Fractional-charge excitations. . . . . » 461
10. The 2/5 and 2/7 states . . . . . » 462
11. Conclusions . . . . . » 463

JOHN D. DOW – Localized perturbations in semiconductors.

1. Introduction . . . . . » 465
   1·1. $GaAs_{1-x}P_x$ . . . . . » 465
   1·2. Column V site impurities N, O, S and Se in $GaAs_{1-x}P_x$ » 466
2. The Vogl model of electronic structure . . . . . » 467
3. The Hjalmarson *et al.* theory of deep impurity levels . . . » 470
   3·1. Qualitative remarks . . . . . » 470
   3·2. Energy scales and the nature of the theory . . . . . » 472
   3·3. Hjalmarson theory of deep levels . . . . . » 475
4. Qualitative physics . . . . . » 477
5. Evidence supporting the theory . . . . . » 480
   5·1. Wave functions . . . . . » 481
   5·2. Deep levels in II-VI compound semiconductors. . . . » 481

5·3. Sankey's theory of paired defects . . . . . pag. 482
5·4. Surface defects and Schottky-barrier heights . . . . . » 484
5·4.1. Core excitons at surfaces . . . . . » 484
5·4.2. Defects at surfaces . . . . . » 485
5·4.3. Schottky-barrier heights . . . . . » 486
5·4.3.1. Bardeen's model of Fermi-level pinning » 486
5·4.3.2. Spicer's native-defect model. . . . . » 487
5·4.3.3. Allen's theory of Schottky-barrier heights in III-V semiconductors . . . . . » 487
5·5. Intrinsic surface states . . . . . » 488
6. Metastable alloys . . . . . » 489
7. Summary . . . . . » 491

M. SCHLÜTER – Quantum theory of localized defects.

1. Introduction . . . . . » 495
2. Scope of the problem . . . . . » 496
3. Theoretical tools . . . . . » 498
3·1. Density-functional theory . . . . . » 498
3·2. Norm-conserving pseudopotentials . . . . . » 500
3·3. The defect Green's function methods . . . . . » 507
4. Defects in semiconductors . . . . . » 511
4·1. The vacancy in silicon . . . . . » 511
4·2. Capture-enhanced migration of aluminum in silicon . . » 523
5. Conclusions and summary . . . . . » 531

C. CALANDRA – Electron states at semiconductor interfaces.

1. Introduction . . . . . » 536
2. Outline of the theoretical method . . . . . » 537
3. The semiconductor-vacuum interface . . . . . » 539
4. The semiconductor-metal interface . . . . . » 544
5. The antimony-on-GaAs (110) system . . . . . » 550
6. Conclusions . . . . . » 555

A. C. LEVI – Atom-surface scattering and surface physics.

1. Elastic scattering. . . . . » 558
2. Bound-state resonances . . . . . » 563
3. Debye-Waller factor . . . . . » 567
4. Inelastic scattering . . . . . » 569
5. Adsorbates. . . . . » 572
6. Smooth *vs.* rough surfaces. . . . . » 574

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