

**Die Kunst of Phonons**  
**Lectures from the Winter**  
**School of Theoretical Physics**

# **Die Kunst of Phonons**

## **Lectures from the Winter School of Theoretical Physics**

Edited by

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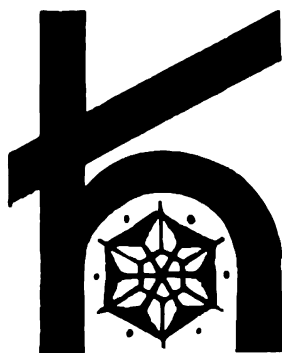
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## FOREWORD

Between 15 and 27 February 1993, the XXIX Winter School of Theoretical Physics was held in the Hotel Gwarek in Kudowa Zdrój, Poland. The present volume contains the proceedings of the Winter School.

In keeping with the name *Die Kunst of Phonons*, the School was dedicated to the physics of phonons. Historically the field of phonons has been a conglomeration of various directions related only by the fact that phonons were involved. The subject has matured greatly and it is now possible to speak of a field of phonon physics proper. Further, it is possible to speak of many of the phenomena seen in phonon physics as being, truly, beautiful. As the object of the book is to present tutorial reviews of the state of the art (Kunst) together with the fact that the state of the art often times reveals beautiful phenomena (more Kunst) we chose a title that reflected this and was also arresting, forcing the prospective reader to stop and reconsider his preconceptions about phonon physics. The use of the german word (with its echoes of Bach's "die Kunst der Fuge") enhances the effect on the prospective reader.

The School was the second Winter School organized by the Institute of Theoretical Physics of the University of Wrocław on this topic and, to certain extent, reviewed the progress that has been achieved in this field over the past six years. The previous XXIII School was held in 1987 at Karpacz, the dominant theme of which was the dynamics of phonons, the kinetics of gases of phonons and their interactions with electrons being treated in less detail during the XXIII School.

The first week of the XXIX School was dedicated chiefly to the interaction of 3D phonons with low dimensional gases of charge carriers (1D and 2D gases of electrons and holes). The study of these interactions provides a deeper understanding of the properties of condensed matter. Simultaneously, the results of this research are of importance for the development of modern technology. Two-dimensional electron gases are used in field-effect transistors (used in satellite communications) and, at room temperatures, the interaction of electrons with phonons is the most important factor limiting the speed of these transistors. The newest experimental and theoretical results relating to low dimensional gases of charge carriers were presented in a series of lectures by P.N. Butcher, L.J. Challis, W. Dietsche, M.V. Entin, A.I. Kopeliovich, A. Shik and V. Karpus.

In the interaction of low dimensional gases of charge carriers with phonons, phonon focussing plays a very important role. A. Every presented a very detailed review of aspects of phonon focussing. In the future, this phenomenon will most certainly be used as a technique for the nondestructive testing of technically valuable materials,

e.g. composites and building materials. For surface waves, the phenomenon of phonon focussing has been predicted and studied theoretically. This has now been seen experimentally by Kolomenskii and Maznev. The latter author attended the School and presented these results.

During the first week, there were also three lectures on the physics of fullerenes. The lecturers were K. Prassides, K. Rapcewicz and J. Stankowski. Lectures devoted to the physics of molecular crystals and glasses were also delivered by V.G. Manzhelii and L.A. Turski.

The second week was dedicated to, among other things, phonon-mediated detectors of elementary particles. The lecturers were H. Kraus and R. Gaitskell. Construction and study of such detectors is the subject of very vigorous research in contemporary experimental particle physics. It is hoped that with the help of such detectors, the neutrino and the particles comprising dark matter will be observed.

Another, important topic covered in the second week was the kinetic of phonons. M. Meissner and P. Strehlow presented research on the thermalisation of phonon pulses at low temperatures and gave a theoretical discussion of it. In these extraordinarily subtle experiments, M. Meissner has proven the existence of a hierarchy of relaxation times which are related to local equilibrium states. S. Ivanov discussed the problem of the crossover from ballistic to diffusive motion of phonon beams while I.I. Tartakovskii and D. Kazakovtsev presented very interesting experimental results on the evolution of hot spots and theoretical attempts at understanding. Hot spots occur on the surface of a crystal as a result of the crystal being irradiated by intense beams of particles or radiation. It is expected that a hot spot should occur inside a crystal as a result of the thermalisation of the high energy elementary particles.

A.M. Kosevich presented results of calculations of the density of states of energy for layered structures. The method used by him does not require phonons and is not limited to harmonic and perturbation methods. Recent progress in using the effective potential method in the classical Monte Carlo calculations of the thermodynamic properties of crystals was reviewed by G.K. Horton while the subtleties of quasimomenta in condensed media were discussed by A. Thellung.

Many of the lecturers also gave introductory lectures to the participants of the Kindergarten of Theoretical Physics and we would like to express our appreciation on behalf of the participants of the Kindergarten.

For the first time in recent memory, two poster sessions were held during the course of the School. This allowed the participants of the School to present their researches to the lecturers of the School, thereby providing them with a chance to discuss with and receive advice on their work from leading researchers in the field.

The XXIX School was generously sponsored by the University of Wrocław, the State Committee for Scientific Research, and the Polish Academy of Sciences. The Stefan Batory Foundation and the WE-Hereaus-Stiftung, which is administered by the Deutsche Physikalische Gesellschaft, sponsored all of the participants from the new republics of the former Soviet Union.

The papers in these proceedings underwent a refereeing process which was mainly undertaken during the School itself. We are grateful to the lecturers of the School for their efforts. We also wish to thank W. Gańcza, Cz. Jasiukiewicz, G. Jastrzębski, J. Lorenc, Z. Petru, P. Siemion, Z. Strycharski, M. Wilczyński, and R. Zossel for their untiring help during the School.

Finally we would like to express our gratitude to Ms. A. Jadczyk for her herculean

efforts in assisting us with the technical aspects of the preparation of the manuscripts.

Tadeusz Paszkiewicz  
Krzysztof Rapcewicz

30 May 1993  
Wrocław

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