

The Mechanical Behavior of Electromagnetic Solid Continua

edited by G. A. Maugin

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THE MECHANICAL BEHAVIOR OF ELECTROMAGNETIC SOLID CONTINUA

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Edited by

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THE MECHANICAL BEHAVIOR OF
ELECTROMAGNETIC SOLID CONTINUA

INTERNATIONAL UNION OF THEORETICAL
AND APPLIED MECHANICS

INTERNATIONAL UNION OF PURE
AND APPLIED PHYSICS



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EDITOR'S PREFACE

The rapid development of different branches of technology and applied physical sciences in the last decade has revealed the importance of the subject matter of electromagnetic interactions in deformable solids. It is with the aim of providing a forum to stimulate the exchange of ideas among research workers of various backgrounds (mechanical sciences, applied mathematics, solid state physics, electrical engineering) as well as to make informations available to potential users that the Editor proposed in 1980 to the Bureau of the International Union of Theoretical and Applied Mechanics that an IUTAM symposium should be held in Paris in a near future; This symposium should be devoted to the discussion of the various mechanical behaviors of electromagnetic deformable solids and electro-magneto-mechanical interactions, their modelling and their applications to statical and dynamical problems and to engineering devices. Although the International Union of Theoretical and Applied Mechanics faced such a proposal for the first time, a meeting pursuing a rather similar object, but at a more theoretical and speculative level, had been previously organized in Warsaw in 1975 through the initiative of specialists of the theoretical mechanics of the Society of Engineering Science (U.S.A.) and the Polish Academy of Sciences. While the present editor enjoyed this first meeting, it was clear to him that any real communication with physicists and electrical engineers was lacking, since these latter were practically absent from the meeting. Therefore, the decision of IUTAM to ask the International Union of Pure and Applied Physics, IUPAP, to join in the sponsorship of the Paris symposium may be considered as a definite step forward to a real dialogue between "mechanicians" and their privileged partners. In such a field of research and development much good will is needed and various approaches, methodologies and techniques can be put together to the benefit of all, on the obvious condition that a minimum of understanding be reached through a common language or an efficient "translation". It is the conviction of the Chairmaa that this has been achieved at the Paris Symposium, although positive results and cross-disciplinary collaboration will probably take some time to show up and develop to a marked degree. Indeed, out of the eighty five active participants⁺ in the symposium from nineteen countries, forty five came from University departments or laboratories of theoretical and applied mechanics, applied mathematics and mathematical physics, twenty nine came from University departments or laboratories of applied physics, solid state physics and electrical engineering and eleven came from laboratories of private companies or government agencies devoted to research and development in various fields of physics, electronics and electrical engineering. For speakers the proportions are thirty five, twenty one and three, respectively, for these three categories. The slight over-representation of the first category is justified both by the fact that the idea of this interdisciplinary symposium was initiated by people from the school of mechanics and by the fact that it is the mechanical behavior of the materials under study which provided the driving force in the discussion. Nonetheless, the concensus may have been large enough since, independently of their origin and initial scientific inte-

+ This figure was fixed in agreement with the recommendations for IUTAM symposia. Originally, 250 scientists were contacted through a first circular in 1982.

rests, many participants stayed for a large portion of the programme in spite of the variety of problems and technical jargons, the extremely busy time table and the exceptionally warm weather which should have attracted more participants in the cafés of Paris if it were not for the interest in the lectures.

We hope that this marked interest and conviviality are reflected in the general lectures and invited contributions printed in this volume. With a few exceptions due to occasional changes in the programme, they are here printed in the order in which they were delivered at the symposium with titles of parts added for the publication with a view to helping the reader. These titles reflect essentially the various states of dielectricity, electric conduction and magnetism of the studied materials. Three parts are distinctly important, namely, the acoustoelectricity of dielectric crystals, the magnetoelasticity of magnetically ordered bodies and the magnetoelasticity of electrically conducting structures. This is no mere chance. Nor does it result from an arbitrary choice from the Scientific Committee. Rather, this emphasis reflects the common interest of both theoreticians and engineers for problems which directly materialize in devices and large-scale techniques, the well-known electroacoustic devices in the first case, the intriguing problem of order-disorder transition in the second one and the elaboration of controlled--fusion reactors and magnetically levitated vehicles in the third one. Evidently then, there could be found no better suited local to house the symposium than the ECOLE SUPERIEURE DE PHYSIQUE ET DE CHIMIE INDUSTRIELLES of the City of Paris, with the shadows of Pierre Curie and Paul Langevin following the participants and reminding them constantly of the problems of symmetry and the efforts to apply basic science to useful devices. Marie Slodowska-Curie, Irène, her daughter, and Frédéric Joliot-Curie would have been very pleased to hear about mechanical problems applied to the structure of controlled-fusion reactors, while Marie Curie would have enjoyed the visit of so many Polish scientists. Professor Pierre-Gilles de Gennes, Head of the School, and Professor J. Badoz, its Scientific Director, must be heartfully thanked for the hospitality offered to the symposium. We want to believe that this is more than a mere symbol of cooperation between physicists and "mechanicians", neologism notwithstanding.

The symposium was arranged by members of the Laboratory of Theoretical Mechanics and the Laboratory of Acoustoelectricity of the Pierre and Marie Curie University in Paris. Special thanks go to Professor E. Dieulesaint and his group who were instrumental in the local organization. The financial and technical support from I.U.T.A.M. and I.U.P.A.P., the Centre National de la Recherche Scientifique (Département des Sciences Physiques pour l'Ingénieur), the Commissariat à l'Energie Atomique, Electricité de France, I.B.M.-France, Thomson-C.S.F., Rhône-Poulenc, the Association Universitaire de Mécanique and the United States Army Research, Development and Standardization Group, U.K., is gratefully acknowledged. Thanks are also extended to the speakers, to the members of the International Scientific Committee, to the Chairmen of the sessions, to the members of the Local Organizing Committee and, last but not least, to Mrs. Frémont and Mrs. Lazaro who have had the kindness to help us in this enterprise.

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Paris, July 17, 1983

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