TABLE OF CONTENTS

PREFACE

This book is based mostly on the reports presented at the XVth International Jahn-Teller Symposium on Vibronic Interactions in Crystals and Molecules and NATO Advanced Research Workshop Colossal Magnetoresistance and Vibronic Interactions that took place at Boston on August 16-22 of the year 2000.

This is the first time the Symposium took place in the USA where recently the giant splash of the attention to the Jahn-Teller effect occurred. This tremendous interest to the field all over the world is reflected not only in the numerous publications in many American and European Journals, but additionally in the Symposium's participation of the leading scientists from the well known Universities, National Laboratories and industrial companies, which was the largest in the history of the Symposium.

The renaissance of the Jahn-Teller physics is closely related to the three fundamental discoveries in science. The most significant among them is the discovery of high-Tc superconductivity by K.-A. Muller and G. Bednorz, for whom the "Jahn-Teller idea" was the motivation in their search. The result of this search is well known – a wide spectrum of the Jahn-Teller ion based materials with Tc between 24K and 135K were found. The second discovery is the existence of a new polymorph of carbon – the C_{60}. The microscopic analysis of all physical, chemical and biological properties of the buckyballs is based on Jahn-Teller type of interactions. The third is colossal magnetoresistance. This phenomenon was recently rediscovered in the manganese oxide compounds and attracts attention not only for its very rich physics but also for its very promising applications in industry. And here once again the Jahn-Teller ion – ion with orbitally degenerate or pseudo degenerate electronic ground state – plays the major role in the most of the material properties.

Turning again to the particulars of the XVth Jahn-Teller Symposium, we would like to comment on one of its distinguishing features. For the first time, the father of the Jahn-Teller effect, Prof. Edward Teller participated in the Symposium. While his illness restricted him from coming to Boston and delivering his talk at the time of the Symposium, we were able to meet him in advance and to record his greeting and a presentation to the participants. His brief historical remarks, opinions on the role of the Jahn-Teller effect in Materials Science and high-Tc superconductivity, and some of his novel ideas will be of interest to the readers.

It is our hope that the book will be helpful to the scientists interested in colossal magnetoresistance, high-Tc superconductivity, buckyballs, and new magnetics with orbital degeneracy. Quite often, the new enthusiasm in one of the science fields is accompanied by "rediscoveries". This book should save some work time for those interested in the electron-phonon interaction at orbital degeneracy – the Jahn-Teller effect, - while, of course, it does not contain ready solutions to many of the problems.

One of the goals of the XVth Jahn-Teller Symposium was to bring together scientists from different fields – physics, chemistry, biology--, who are working on Jahn-Teller problems, for developing a "common language and common ideological platforms". That is why in the Program of the Symposium the different subject presentations are next to each other.

The structure of the book corresponds in this sense to the structure of the Symposium. There are "short" (4-5 pages) and "long" (8-16 pages, related to the invited talks) manuscripts on different subjects. The reader will find in the book, for example, the results of the experimental studies and reviews on colossal magnetoresistance (J. Goodenough and Zhoo, D. Looca, C. Nelson), chemical point of view on high-Tc superconductivity (W. Grochala and R.Hoffmann) and materials science of perovskites (M. Atanasov and D. Reinen), vibronic interactions in biological systems (M. Belinski, S. Stavrov) and molecules (C. Bates, J. Dunn, M. Abou-Gantous), theoretical studies of colossal magnetoresistance (L. Gor'kov, V. Kresin, and M. Dzero) and structural phase transitions (M. Kaplan, B. Vekhter, G. Zimmerman), high-Tc superconductivity (A. Bratkovsky, V. Polinger, D. Haskel, A. Stern), fundamental questions of the Jahn-Teller effect (I. Bersuker, A. Ceulemans, Q. Qiu). However, all the manuscripts on the different subjects have a commonality, the Jahn-Teller, or vibronic, approach. This should be of interest to the reader from any of these fields.

Of course, it is difficult to convey the atmosphere of excitement and creative energy that pervaded the Symposium. As the participants are acknowledging, the Symposium and the NATO ARW were most successful. This was made possible by the support of the meeting's sponsors. The financial support of NATO's Science Division was crucial for the success of the Symposium. The organizational and financial help of the hosts of the meeting Boston University and Simmons College can not be overestimated. The support of MKS, Elsevier Publisher, and Mitre is gratefully acknowledged.

We would like to thank all authors for their contributions and time it took them for preparing the manuscripts.

Michael Kaplan,
George Zimmerman.

Professor Edward Teller's Address to the Meeting Participants

Edward Teller
Fairchild Institute, Stanford University, Stanford, CA 95305

Key words:

Abstract: This address, recorded by M.D. Kaplan and G.O. Zimmerman on December 11, 1999, is a transcript of a video tape which was presented as the first contribution to the meeting. It contains greetings, a brief history of the Jahn-Teller effect discovery, and ideas of temperature induced high-Tc superconductivity and related properties.

It is a very great pleasure to be here, I believe, at the XVth Symposium, on what people have called the Jahn-Teller effect. The XVth but the first in the United States.

I want to start by thanking Professors Kaplan and Zimmerman to get me to this meeting and particularly also Dr. Kresin who made it absolutely necessary that I say a few words, which I shall now do.

I want to start with repeating something that I said in the past, how it all came about. I used to be, some 60 years ago, working in Gottingen with a nice student by the name of Renner and I told him:

"Let's look at it, three-atomic molecule of carbon dioxide, and get the electronic excitations mixed with the vibrations that destroy the symmetry." What a nice paper (resulted from this investigation)!

Then he (Renner) had to take over the business of his father. He was a good physicist; never had the opportunity to exercise it, and died.

I then came to Copenhagen and got into a violent fight with my very good friend Lev Landau. He said that it can not be. If there is electronic degeneracy of the polyatomic molecule, the molecule will move and split the degeneracy as a result of interactions of electrons with atoms' motion. I said

M.D. Kaplan and G.O. Zimmerman (eds.),
Vibronic Interactions: Jahn-Teller Effect in Crystals and Molecules, 1–3.

no, and we had a fight. And surprisingly and absurdly I won even though Lev was the very-very great physicist. He agreed it could be so.

And look how it can be. I knew a very good expert in symmetry by the name of Jahn. I asked him to help me to check, if this opportunity to show that Landau is wrong is unique, or are there other kind of molecules which can be electronically degenerate and symmetrical and stable. And by looking to all symmetries we found, that Lev Landau is absolutely always right except for molecules where all atoms are in a straight line, which can be degenerate and stable. Otherwise, electronic degeneracy leads to deviation of the symmetry and the splitting of the degenerate level. I suspected rightly that all kinds of other things will follow and also suspected rightly that it would be very-very hard to understand and analyse.

The 15 Symposia show that indeed it was hard and interesting. Of the very many effects of degenerate electronic states, of the Jahn-Teller effect, I want to use one, perhaps the most striking one, superconductivity. Superconductivity is not due to the electronic degeneracy. It is due to something similar-to the density of electronic states. No mysteries, many electronic states in a small energy interval, will, of course, in the limit, lead to degeneracy. That situation can give rise to superconductivity. And, in particular, has given rise, in recent years, to a remarkable phenomenon of high temperature superconductivity.

(In another case it is possible that superconductivity is induced by high temperatures.) That situation -the high temperature induced superconductivity- creates something different from the usual case. The usual effect of high temperatures creates disorder. Could high temperature create something like order and superconductivity connected with order or rather with high density of electronic states? It appears that the answer is yes. It appears that we can have high temperature superconductivity up to more than 100K. Because we have a mini-degeneracy of the lower states and then, at higher temperature, the population of the higher states increases and the high electron density can result at the higher temperature. That is something to be observed. The result is to see something not only at low temperatures, but at temperatures that become more and more high.

I do not want to talk to you too much. But I want to put before you a question. I do not know the answer to this question, but I am very much interested in it. What has been found is the superconductivity persisting at high temperatures. My question is: can superconductivity be not persisting at high temperatures, but be created at high temperatures. A situation, when in the lowest state encountered in perovskite crystals, the superconductivity continues to exist up to more than 100K. Could it be that the lowest state is not symmetric enough to create superconductivity? If you raise the temperature, you excite a multielectronic state that is not only a high density electronic state but is sufficiently coupled with vibrations to bring about a propagating wave. This wave is stable enough so that it can carry electricity in a stable manner and create superconductivity.

I mean this question specifically in hope to make you rather interested. But I want you to remember that if you find these higher temperature states, they may have not only the possibility to be superconducting. They may have the possibility of peculiar new crystal formations, crystal transformations and effects like magnetism, such as has been observed in manganese compounds, but not yet under conditions that I am telling you. It will turn out that we could construct, by looking at nearly symmetrical crystals, situations where superconductivity and other intrinsic phenomena could be available at room temperature, which would be of great practical and theoretical interest.

I am sorry not to be able to be today with you. I am over 90 years old and I can no longer walk, but I still barely can talk. Therefore, greetings and good luck.