Final Report for Period: 09/1997 - 08/2000 **Submitted on:** 08/25/2000

Principal Investigator: Freericks, James K. **Award ID:** 9722782

Organization: Georgetown University

U.S.-Croatia Research on the Effect of Nonconstant Electronic Density of States on the Integrated Theory of Superconductivity in real materials

Project Participants

Senior Personnel

Name: Freericks, James
Worked for more than 160 Hours: Yes
Contribution to Project:
Freericks hosted Zlatic twice at Georgetown with support from this grant, and visited Croatia two times. Work on grant projects was most concentrated during these periods of exchange.

Name: Zlatic, Veljko
Worked for more than 160 Hours: Yes
Contribution to Project:
Zlatic visited Georgetown twice under support of this grant for periods of one month each. Freericks visited Zagreb for one month periods two times during the grant. Support for these activities came jointly from the NSF and from the Croatian Ministry of Science (the latter being approximately $2,000 per year). During these exchanges, the most concentrated work on the project took place.

Name: Lemanski, Romuald
Worked for more than 160 Hours: No
Contribution to Project:
Romuald Lemanski was a visitor at Georgetown during the Spring of 1999. During that time a collaboration between him, Freericks and Zlatic was began that is examining the f-electron spectral function of the Falicov-Kimball model in the hopes of applying these results to the physics of YbInCu4.

Post-doc

Name: Quandt, Alex
Worked for more than 160 Hours: No
Contribution to Project:
Alex Quandt will travel to Croatia in the summer of 2000 to work on transport problems in correlated systems with Freericks and Zlatic.

Graduate Student

Undergraduate Student

Organizational Partners

Institute of Physics, Zagreb, Croatia
The Institute of Physics hosted the PI for one month per year.
Office space, access to computers, and office
supplies were provided. In addition, the Institute supported all
living expenses of the PI during this period through a matching grant
from the Croatian Ministry of Science.

Other Collaborators or Contacts

Mark Jarrell from the University of Cincinnati.
Woonki Chung from Georgetown University.

Activities and Findings

Project Activities and Findings:
We have spent time working on three projects. The first is a systematic examination of perturbative approaches to the electron-phonon problem. The second is a study of anharmonic effects in an electron-classical phonon problem. And the third is a study of the curious metal-insulator transition in Yb In Cu compounds, as described by the Falicov-Kimball model.

Project Training and Development:
We have discovered that all reasonable perturbative approaches to the electron-phonon problem fail at about the same strength of the interaction. The strong-coupling limit is not reachable from the weak-coupling theory.

We have discovered an interesting scaling regime for the anharmonic electron-phonon system where the transition temperature to charge-density-wave order scales with the wave-function renormalization parameter over a wide region of the phase space.

We have also found that the anomalous behavior of many Yb-In-Cu compounds are described remarkably well by the exact solution of a simple Falicov-Kimball model an appropriate parameter region. This may be one of the best systems to be described by this model.

Research Training:
Freericks provided a number of computer programs to Zlatic and Lemanski that solve the dynamical-mean-field-theory for the Falicov-Kimball model. Both Zlatic and Lemanski learned how to use DMFT and worked on modifying and running numerous computer codes for the research project.

Outreach Activities:
During his visits to Croatia, Freericks gave a series of lectures at both the University of Zagreb and the University of Split that described recent results in physics pedagogy that have been developed in the United States. In particular, he gave a set of lectures that describe the active learning techniques developed by the University of Washington Physics Education Group (which Georgetown collaborated with as a test site for the Tutorials in Physics) and he gave a set of lectures describing how to teach quantum mechanics concepts to nonscientists using techniques developed by Richard Feynman, Ed Taylor, Dan Styer, the PI, and Amy Liu.

Journal Publications

J. K. Freericks, V. Zlatic, Woonki Chung, and Mark Jarrell, "Vertex-corrected perturbation theory for the electron-phonon problem with nonconstant density of states.", *Physical Review B*, p. 11613, vol. 58, (1998).) Published
J. K. Freericks, V. Zlatic, and M. Jarrell, "Approximate scaling relation for the anharmonic electron-phonon problem", *Physical Review B (Rapid Communication)*, p. R838, vol. 61, (2000).) Published

Books or Other One-time Publications

Web/Internet Sites

URL(s):

Description:

Other Specific Products

Contributions

Contributions within Discipline:
The scaling theory for Tc in the anharmonic electron-phonon problem sheds much light onto the question of why is it that nearly all theories of real materials, and especially those on superconductivity, neglect anharmonicity, but reproduce the experimental results to very high degrees of accuracy. Our results show that if the anharmonic phonons interact with the same effective strength as the harmonic phonons, then the remaining properties are essentially the same.

Our theoretical results for the Yb-In-Cu systems have stimulated a number of experimental groups to work on issues related to the predictions of the theory, and have found the theoretical model to work remarkably well for a wide variety of experiments in Yb-In-Cu systems.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Science and Technology Infrastructure:

Beyond Science and Engineering:

Categories for which nothing is reported:

Any Book
Any Product
Contributions: To Any Other Disciplines
Contributions: To Any Contributions to Human Resource Development
Contributions: To Any Science or Technology Infrastructure
Contributions: Beyond Science or Engineering