3rd CMD General Conference

The first of the EPS General Condensed Matter Physics Conferences took place in 1980 in Antwerp, the second in 1982 in Manchester and the third from 28 to 30 March 1983 at the Ecole Polytechnique Fédérale de Lausanne. These Conferences are by now well established as indicated by the following numbers:

	1980 Antwerp	1982 Manchester	1983 Lausanne
Participants	~ 600	581	623
Inv. speakers	63	59	66
Plenary Session	9	5	6
Symposia + Gen. inter. Sessions	11	12	15
Contrib. papers	307	350	427

From the point of view of an organiser, there were no major problems with the Conference in Lausanne although the quality of projections in the large lecture hall "Salle Polyvalente" meant that some effort was required to follow the plenary sessions. Otherwise, the atmosphere was relaxed and it was easy to find people and also to find a quiet corner for discussions.

Two satellite meetings materialised. The one on "3rd Metallic Magnetism" is covered below, the second on "Impurity Induced Phase Transitions in $KTaO_3$" had been organised at the EPFL 25-26 March 1983. There have also been two official and several unofficial get-togethers during the Conference.

Students were treated as normal participants, but the Conference paid each a contribution of Sw.Fr. 300.— towards their living expenses; 44 made use of this provision. The Conference has also made its full contribution to the EPS Young Physicists Fund which now is voluntary.

Generally a conference cannot pay its participants. There are, however, always special cases and cases of particular hardship, and the organisers were very fortunate to have returned as a gift from a number of invited speakers from Switzerland, the living expenses paid to them by the Conference, with which they were able to help a number of foreign colleagues. The Organisers would like to express their profound appreciation to their Swiss colleagues.

A good habit which has been introduced is the organisation of an open discussion between the CMD Board and the CMD Members. The open meeting in Lausanne did not quite have the attendance it deserved, but it was quite informative nevertheless.

It is always difficult to judge with any certainty the success of a conference, but from the response received either orally or by mail afterwards, from colleagues numbering about 10% of the participation, it seems that at least two of the objectives of these General Conferences were attained, notably the creation of a European forum for discussions and the possibility of obtaining, with high efficiency, a representative overview of the field.

Abstracts of the papers have been published in the *Europhysics Conference Abstracts* series, Vol. 7B and in the following articles three topics have been picked out to give to the readers of *Europhysics News* a flavour of the rich field that is condensed matter physics today.

Last but not least the Organisers would like to thank the invited speakers and those who contributed to the running of the Conference and send all their best wishes to their colleagues organising the succeeding 4th General CMD Conference of the EPS, 19-23 March 1984 in Den Haag.

W. Czaja

Localization and Interactions

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In the past few years there has been renewed impetus to consider the properties of electrons moving in a disordered medium. It is now over twenty years since Anderson showed in his classic work that a single electron becomes localized and will no longer diffuse if the random potential is sufficiently strong. However, reality is usually a finite density of electrons interacting with each other through the Coulomb interactions. This interaction cannot be treated as a weak perturbation on the single particle problem. For example, it is known that electrons in an ordered medium must have a discontinuous transition as a function of density due to the long range nature of the Coulomb interaction between them. Considerable progress had been made on the separate parts of the problem, but the key question of how the transition from the metallic phase to the localized insulating phases proceeds, remained without a definite answer either from theory or experiment.

The renewed interest and progress on this subject was sparked by a new approach to the problem of a single electron in a disordered medium by Anderson and his coworkers. In a paper in 1979 they (generally referred to by the whimsical title of "gang of four") introduced a single-parameter scaling theory for the problem. Their theory is expressed in terms of the scaling of the conductance of a finite sample with the length of the sample. The critical dimensionality is 2. For dimensionality d < 2, all states are localized, while for d > 2 the states are extended at large values of the conductance but become localized with sufficiently strong disorder — a transition now called the Anderson transition. In two dimensions, d = 2, there are logarithmic divergences even in the limit of large conductance which lead to the conclusion that there cannot be metallic conduction for d = 2 at $T = 0$. This effect is generally referred to as weak localization. Such a conclusion was also obtained independently at that time by Wegner, who mapped the Anderson localization problem onto a field theory, whose scaling behavior was obtained by usual renormalization-group methods.

Shortly afterwards Altshuler, Aronov and Lee found that for d = 2, there was a breakdown of the Landau Fermi liquid description of interacting electrons in the presence of the impurities. Previously it was generally believed that for d = 2 and 3 the presence of impurities would not lead to any important modifications of the Landau Fermi liquid theory. However, Altshuler and co-workers showed that for d = 2 there were corrections which diverged logarithmically and had coefficients of the same order as the divergent terms found by the "gang of four". Dr. Altshuler was invited to talk on this topic at the EPS conference. Regrettably he did not come — a fact which illustrates the difficulties that some of our colleagues continue to face despite the efforts made to normalize scientific relations.

At the EPS meeting a beautiful series of experimental results on two-dimensional films were presented by two speakers, G. Bergmann (Jülich) and Y. Bruynseraede (Leuven). In his talk, Bergmann presented studies on metallic films showing weak localization effects in the resistivity, and an appealing physical discussion of the single electron effects as an interference in the back scattering direction between conduction electrons which are split in pairs of waves. An external magnetic field introduces a magnetic phase shift of the

wave functions so that the interference effect is sensitive to weak magnetic fields — unlike the interaction effect. This very different magnetic field dependence enables the two effects to be separated experimentally. Heavy impurities lead to a large spin-orbit coupling in the scattering process and a rotation of the spin of the electrons. This in turn changes the sign of the interference effect. Thouless had shown that inelastic scattering events lead to a total loss of phase memory and that a study of the temperature dependence of the interference effect determines the inelastic scattering rate. All these features were demonstrated in the series of experiments that Bergmann presented.

Bruynseraede introduced work done by the Leuven group in collaboration with G. Deutscher (Tel-Aviv) which also showed the weak localization effect and in addition studied the interplay of this effect with superconducting fluctuations in Al films that are superconducting at low temperature. This interplay had been discussed theoretically recently by Larkin and the data presented by Bruynseraede clearly verified the theory.

In three dimensions there is a real metal-insulator transition, but over the years there has been no unanimity on whether this transition is continuous or discontinuous. For example, Mott has argued for a minimum value for the conductivity of a metal which requires a discontinuous jump in the conductivity extrapolated to $T = 0\,K$. On the other hand, the scaling theory of the "gang of four" predicts a continuous transition at $T = 0\,K$ with critical exponents for the divergence of the resistivity. Recently the classic system of a doped semiconductor, Si:P, has been investigated in a careful series of experiments by a group at Bell Labs. (G.A. Thomas, M. Paalanen, T.F. Rosenbaum and R.N. Bhatt). They worked at much lower temperatures, down to the millikelvin range, and they performed a very elegant series of experiments using external stress to sweep their samples through the metal-insulator transition. Their results were presented by Paalanen at the meeting, who explained that a continuous transition with no sign of the minimum metallic conductivity had been found, but the critical exponents do not agree with those predicted by the single-electron scaling theory, suggesting an important role for electron-electron effects.

While the theory of the weak localization regime in two dimensions is by now well established, the theory of the metal-insulator transition in three dimensions is still being actively studied. One can use the weak localization theory to give the first terms in the scaling equations but a treatment of the actual metal-insulator transition, and a determination of the scaling behavior including both disorder and interaction ef-

fects, require higher order terms and the solution of a complicated series of scaling equations. This point was stressed by C. Castellani (Rome) who presented the latest theoretical work of this group (C. Castellani, C. DiCastro, G. Forgacs and E. Tahet). The problem is also being studied by Grest and P.A. Lee who recently published results of a scaling approach which gave good agreement with the Bell group's experiments. However Castellani showed that terms neglected in the Grest-Lee approach may influence the results considerably. The progress in this theory by these groups has been impressive but the final word is not yet in.

An alternative approach by the group at Munich (A. Gold and W. Götze), presented by Gold, uses a generalized self-consistent current relaxation theory. Their theory has the advantage that it can be applied to give a general phase diagram of the metal-insulator transition.

The special case of one dimension was discussed by W. Apel, presenting work done with the author in Zürich. He covered the case of materials which are one-dimen-

sional as regards the electronic interaction but do not have a Peierls transition. He showed that the divergences introduced by interactions in $d = 1$ modify the asymptotic behaviour in the scaling theory of "the gang of four" and lead to a transition between a localized insulating state and a perfectly conducting metallic state. He also gave a more intuitive picture in terms of a crossover between quantum and classical transport as the ratio of elastic and inelastic scattering lengths change.

Conclusion

Progress made in the past few years in this field has been remarkable. Not only have spectacular new and unsuspected effects, such as the absence of true metallic conduction in two dimensions been discovered, but also a much better understanding of the metal-insulator transition has been obtained. The goal of a complete understanding, which has eluded us for more than 40 years, is in sight. The talks at the meeting conveyed this progress but gave just a selection of the work underway in many groups in all parts of the world.

Itinerant Electron Magnetism

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Itinerant electron magnetism as a subject had its birth in the 1930's and, after a lengthy period of relative neglect, it experienced a renaissance beginning about 20 years ago. At the present time it has reached an exciting stage of development to which there is no rapid end in sight. Contributing to the evolution of the subject, concerned as it is with the magnetic properties of metals and alloys, are: theoretical sophistication, advanced computations and advances in experimental techniques. All three of these facets appeared in an exciting way at a recent Workshop on 3d metallic magnetism, held in Grenoble on 25-26 March, 1983, and at the 3rd General Conference of the Condensed Matter Division in Lausanne. Itinerancy between these two towns was provided by a bus!

The simplest model of metallic magnetism is that of Stoner to which Mott and Slater had made essential contributions. The itinerant electrons are regarded as being distributed in single particle energy levels with characteristically complicated density of states curves $N(\varepsilon)$. The many-body electron interactions leading to enhanced Pauli paramagnetism or, beyond a certain strength, to itinerant ferromagnetism, are described in this approach by a mean-field approximation. The essential contributions to the mean-field energy I come from intra-atomic Coulomb interactions and, since the resulting Hartree-Fock

approximation is inapplicable, from correlations between antiparallel spins. This approach has been found in the last few years to be a relatively good description of metallic magnetism at $0\,K$, using for this confirmation a theoretical approach called the density functional formalism. Even so, this approach is not always satisfactory: It overestimates the exchange splitting between opposite spins in nickel by a factor of about 2 when compared to the value obtained experimentally using photoemission techniques. However, the greatest controversy at present concerns the description of metallic magnetism at finite temperatures, up to and beyond the Curie point T_c. In the Stoner theory this was based on the straightforward use of Fermi statistics, characterized by the usual distribution function $f(\varepsilon, T)$. A particularly heated controversy concerns the resulting value of T_c, given by:

$$I \int_0^\infty N(\varepsilon) \left| \partial f / \partial \varepsilon \right|_{T=T_c} d\varepsilon = 1.$$

A folklore has developed spontaneously that this T_c is larger, by factors of about 5, than the measured values for iron, cobalt and nickel. However, as was pointed out during the discussion at Grenoble, a value of I, the mean field energy, in agreement with the photoemission data rather than that calculated by the density functional formalism, gives reasonable values of T_c for