

# 2006 Agilent Technologies Europhysics Prize

The EPS and Agilent Technologies are proud to announce that the 2006 Agilent Technologies Europhysics Prize has been awarded to Professors Antoine Georges, Gabriel Kotliar, Walter Metzner and Dieter Vollhardt, for the Development and Application of the Dynamical Mean Field Theory. The Awards Ceremony was held during the 21<sup>st</sup> Condensed Matter Division Conference (CMD21), on Thursday 29 March 2006, in the premises of the Dresden University of Technology, in Dresden (D).

The Agilent Technologies Europhysics Prize, sponsored by the Agilent Technologies Foundation is one of the most prestigious physics prizes presented in Europe. Since 1975, the award has been given to leading scientists in nearly every internationally important area of condensed matter physics. The award is given in recognition of recent work by one or more individuals in the area of physics of condensed matter which represent scientific excellence.

## Citation

Heavy-fermion compounds, high-temperature superconductors and many other materials with unusual properties, such as colossal magnetoresistance in manganites, led to a revival of studies of strongly correlated electron systems. Efforts to deal with correlation effects were already present in the 60's of the last century, in particular in studies of the Mott metal to insulator transition, experimentally observed in materials such as vanadium oxide. The full explanation of this phenomenon is one of the main achievements obtained with the Dynamical Mean Field (DMFT) method introduced by the winners of the 2006 Agilent prize.

The main theoretical paradigms previously available to describe metallic phases, such as electron energy band theory and Fermi-liquid theory, turned out to be inadequate for dealing with strongly correlated electron systems. Even if the insulating

phase could be described in terms of electrons localized at atoms, strongly correlated systems are generically in the intermediate regime where the localizing electron-electron interaction is comparable to and competes with the delocalizing kinetic energy. These two terms are usually schematized via the Hubbard Hamiltonian with an on-site repulsion and with a hopping term between neighbouring sites. The competing effect leads to a variety of physical properties and to rich phase diagrams. The difficulty in dealing with these systems, even when they are schematized in terms of the simplest model Hamiltonian, is due to the intrinsic non-perturbative nature of the problem in the absence of the simplifying aspects of universality available, for instance, in classical critical phenomena. Solvable limits with a well-defined control parameter are therefore of invaluable help in understanding these systems.

Walter Metzner and Dieter Vollhardt introduced the method of dealing with correlated fermions on a lattice by a suitable rescaling of the hopping in the large dimensionality limit or more properly, in the limit of a large lattice coordination number, whose inverse is the control parameter. In this way they succeeded in maintaining the dynamical competition between the kinetic energy and the Coulomb interaction along with the discovery of the main simplification of the method, namely the locality of perturbation theory in this limit.

Antoine Georges and Gabriel Kotliar introduced a considerable technical and conceptual improvement in the construction of the DMFT that produced many applications to physical systems. By relating DMFT to the single impurity Anderson model, the full quantum many-body problem of correlated materials on a lattice or on the continuum was reduced to an impurity, self-consistently coupled to a bath of electrons. The single site problem retains the full dynamics of the original problem. In analogy with the classi-

cal mean field theory where a single degree of freedom (e.g. a spin on a site) is immersed in the self-consistent effective field (the Weiss field) of the remaining degrees of freedom, here a local set of quantum mechanical degrees of freedom on a single site are linked to the reservoir of the electrons via a frequency dependent function which plays the role of the self-consistent mean field and allows the electrons to be emitted and absorbed in the atom. A local description of correlated systems is achieved, which is amenable to calculations while the main features of competition between itinerancy and locality are still present.

Various extensions of the method are now considered e.g.: realistic one-particle and Coulomb interaction aspects are included by combining the local density approximation method and DMFT; short range space-correlations are introduced by switching from a single atom to a cluster.

The very successful applications of the method have covered numerous phenomena at the heart of the present research activity. To quote just a few of them besides the important success of Georges and Kotliar in explaining the metal-insulator transition, we can mention the doped Mott insulator, the competition of spin, charge and orbital order, the interplay between correlation and the electron-phonon interaction, the phonon spectrum of delta Plutonium and some general features related to quantum criticality.

In conclusion the DMFT represents one of the most powerful approaches to strongly correlated electron systems. In addition to the number of successes of the DMFT in model systems and realistic calculations, the applications of the method are still increasing and many extensions and developments are nowadays the object of the research of many groups worldwide. ■

▼ L. to R. Antoine Georges, Gabriel Kotliar, Dieter Vollhardt and Walter Metzner

