Hund metals: A new paradigm in correlated electron systems

L. Fanfarillo[1], E. Bascones[1,*]

[1]*Instituto de Ciencia de Materiales de Madrid*
* leni@icmm.csic.es

Our knowledge of the electronic properties of solids is based on band theory, which treats electrons as independent particles placed in a periodic potential. The electrons are delocalized and the electronic states form energy bands with well-defined lattice momentum **k**. Band theory has allowed us to understand the metallic or insulating character of most of the materials. In correlated electron systems band theory find difficulties to explain many experimental results. The failure is most dramatic in the case of Mott insulators, predicted to be metallic by band theory.

As the system approaches the metal-insulating Mott transition the electrons become localized at the atomic sites. In the Mott insulating state the electronic states are better described as localized spins in real space rather than in terms of energy bands in k-space. The Mott transition and the associated localization of the electrons is a consequence of the electronic repulsion between the electrons and it is very sensitive to the electronic filling of the atomic bands. The electronic instabilities of a material (magnetism, superconductivity, …) are strongly dependent on the localized or itinerant character or the electrons.

Mott physics has been widely studied in single orbital systems using the simplest possible model: the Hubbard model. In this model the only interaction included is U, the repulsion between the electrons which are in the same site and orbital. With increasing U the electrons become correlated, but only at half-filling (1 electron per site) the electrons become localized and the system shows insulating behavior. Mott physics plays an essential role in the phenomenology of the high-temperature superconductors based on copper: the cuprates. In the cuprates the superconductivity appears when an antiferromagnetic Mott insulator is doped.

Several orbitals per atomic site have to be included in the description of iron high-temperature superconductors[1] and of many oxides. In the last years it is becoming clear that the Hund's coupling, which is behind the well-known Hund rules, has a strong impact on the strength of correlations. A new concept, the Hund metal, has been coined to name the correlated metallic state with correlations determined by Hund's coupling. In the talk I will introduce Mott physics and discuss the nature of correlations in multi-orbital systems. I will make special emphasis on the properties of Hund metals[2] and its similarities/differences with doped Mott insulators.

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[1] E. Bascones, B. Valenzuela and M.J. Calderón, arXiv.1503.04223

[2] L. Fanfarillo and E. Bascones, arXiv:1501.04607