STRONG ELECTRON CORRELATIONS IN LOW-DIMENSIONAL SYSTEMS. EXPERIMENTS

Silvio Modesti

PROBLEMS:

Strong electron-correlation effects determine the physics of several very interesting and potentially useful materials such as the high temperature superconductors, the materials with colossal magnetoresistance, with spin-liquids, with metal-insulator transitions…..

Many of these materials are too complex to be well described by the present theoretical and computational methods.

We need simpler model systems (toy systems) to test and improve our understanding of the many-body effects, systems that can be tackled by both theory and experiment**. If we fully understand them the theory can advance and design new surprising and useful materials.**

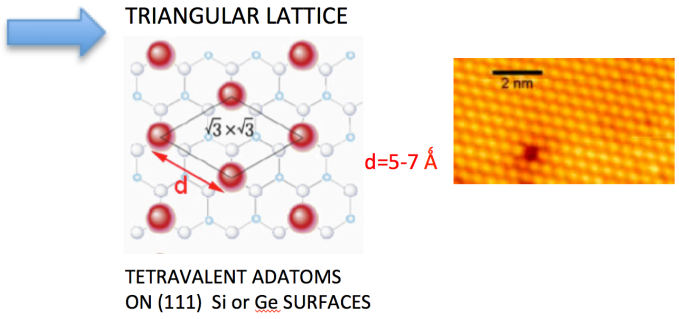
EXAMPLES:

1/3 of a monolayer of Sn on Si(111)

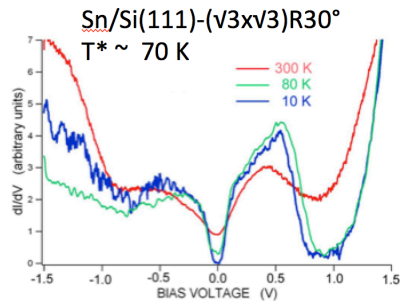
We demonstrated that this simple system undergoes a metal-insulator transition due to electron correlations. Now the theoreticians are able to simulate the transition (Mott-Hubbard system).

Open problems: are the spins localized? Are the spins ordered?

The surface



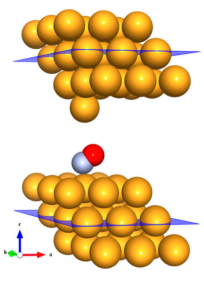
The metal-insulator transition



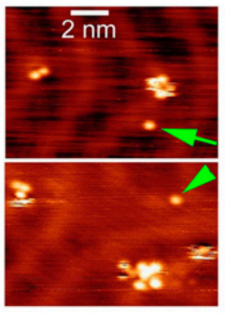
The simplest Kondo system

Can theory predict the ground state of the simplest Kondo system ab initio? Only partially, and we are learning why.

One NO molecule between contacts

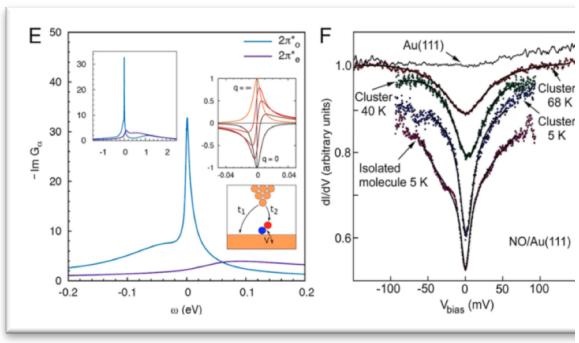


Single NO molecules



Conductance

Theory Experiment

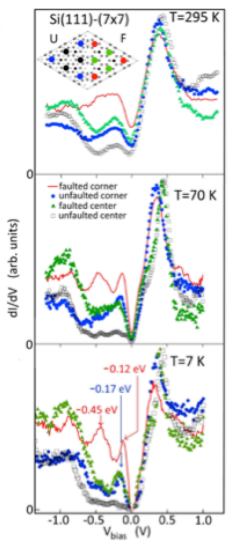


The ground state of Si(111)-7x7

The Si(111) surface is the most studied surface. Do we know its ground state? No, we do not.

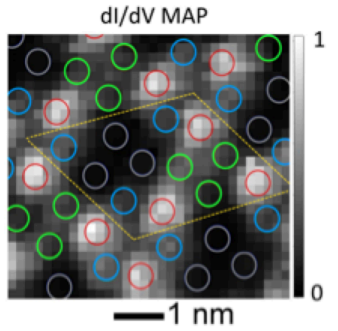
You read in the textbooks that this surface is a two-dimensional metal, but we demonstrated that the ground state is an insulator. The theoretical simulations are not yet able to explain this.

What are the roles played by the electron correlation, the electron-phonon interaction, the orbital degrees of freedom?



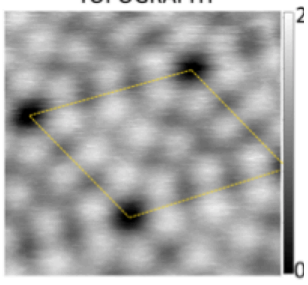
The metal-insulator transition

dI/dV MAP



The localization of charge at 6 K

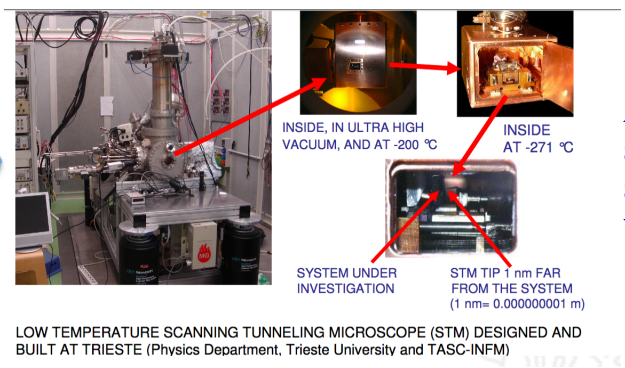
TOPOGRAPHY



The structure of the surface at the atomic level

METHODS:

Tunneling spectroscopy at 6 K, STM, high-resolution low-temperature photoemission with synchrotron radiation. We plan to use also ultrafast photoemission, Mossbauer spectroscopy with synchrotron radiation,…



An experimental set-up: system for scanning tunneling spectroscopy at 6 K in ultra-high vacuum

Some publications:

S. Modesti, L. Petaccia, G. Ceballos, I. Vobornik, G. Panaccione, G. Rossi, L. Ottaviano, R. Larciprete, S. Lizzit, A. Goldoni "**Insulating Ground State of Sn/Si(111)-(√3x√3) R30°**" Physical Review Letters **98**, 126401 (2007)

S. Modesti, H. Gutzmann, J. Wiebe, and R. Wiesendanger "**Correction of systematic errors in scanning tunneling spectra on semiconductor surfaces: The energy gap of Si(111)-7×7 at 0.3 K**" Phys. Rev. B **80**, 125326 (2009)

R. Requist, S. Modesti, P. P. Baruselli, A. Smogunov, M. Fabrizio, and E. Tosatti "**Kondo conductance across the smallest spin ½ radical molecule**" PNAS **111**, 69 (2014)

R. Requist, P. P. Baruselli, A. Smogunov, M. Fabrizio, S. Modesti and E. Tosatti, **Metallic, magnetic and molecular nanocontacts**, Nature Nanotechnology **11**, 499 (2016)

S. Modesti, P. M. Sheverdyaeva, P. Moras, C. Carbone, M. Caputo, M. Marsi, "**Orbital redistribution in the low-temperaure insulating phase of Si(111)-7x7**", in press

Collaborations:

SISSA, Elettra, Université Paris-Saclay, ESRF, CNR

Contact:

modesti@ts.infn.it