Teaching: **Standing wave and local spectroscopy using an STM**
Lecturer: **Dr. Laurent Simon** (IS2M LRC7228 Mulhouse)
Lecture: 8/02/11 (14h-16h), 10/02/11 (14h-16h)
Location: Physics tower, room 315

Abstract

Standing wave and local spectroscopy using an STM

The interaction of a 2D electron gas with defect surfaces generates standing waves pattern which can be directly imaged by Scanning Tunneling Microscopy. This is one of the most important manifestations of electron-electron interactions. In this lecture we will give a general description of the screening in a free electron gas (Thomas Fermi, Lindhard Theory). We will then give generalities on the band structure of noble metals; the generation of surface states (for example Shockley states) and their interaction with surface defects. We will describe how to measure directly the local density of states using Lock-in amplifier (Scanning Tunneling Spectroscopy and dI/dV map). With the use of dI/dV map images we will see how it is possible to measure the Schockley states band structure dispersion. An original method to use the standing wave pattern obtained with an STM was first initiated by Sprunger et al[1] who showed the possibility to use STM to image the surface Fermi contour of a metal surface directly by performing the power spectrum of a topographic image of a complex "electron sea" pattern. He opened a new STM approach called Fourier Transform Scanning Tunneling Microscopy. We will show that the power spectrum features can easily be deduced in a first approximation on the basis of the joint density of state (JDOS), which can be evaluated by a simple geometrical construction. This opens the route to characterize more realistic surface Fermi contour. Starting from simple isotropic Fermi contours provided by Shockley states in metals, we will illustrate the possibilities of this approach and show how the JDOS is a probe of the contour topology for more complex systems such as high Tc Supraconductor[2], semi-metal[3] and more recently graphene[4] which provides interesting topological singularities.

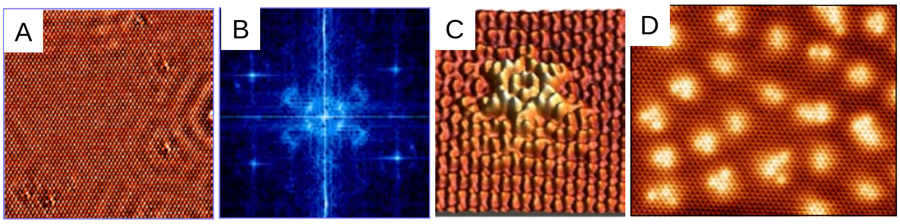

Figure : A) Standing waves pattern and corresponding power spectrum of the 2D FT (B) on Erbium disilicide. C) Standing waves around a substitutional point defect in Bilayer graphene. D) Topographic image of interacalated gold clusters under a graphene monoloyer.

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[1] Sprunger P T, Petersen L, Plummer E W, Lægsgaard E and Besenbacher F 1997 *Science* **275** 1764

[2] McElroy K, Simmonds RW, Hoffman J E, Lee D-H, Orenstein J, Elsaki H, Uchida S and Davis J C 2003 *Nature* **422** 592

[3] Vonau F, Aubel D, Gewinner G, Pirri C, Peruchetti J C, Bolmont D and Simon L 2004 *Phys. Rev.* B **69** 081305R, Vonau F, Aubel D, Gewinner G, Peruchetti J C, Bolmont D and Simon L 2005 *Phys. Rev. Lett.* **95** 176803

[4] L. Simon et al Eur. Phys. J. B **69**, 351-355 (2009). B. Premlal et al APL **94** 263115.1 (2009), G. M. Rutter et al Science 317 (2007) 219. I. Brihuega et al Phys. Rev. Lett. 101 (2008) 206802, M. Cranney et al EPL 91 (2010) 66004.