# SURFACE STATE DIMENSIONALITY MODULATION ON CURVED Bi(111)

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Bismuth is a semimetal whose surface shows better metal behaviour than its bulk counterpart due to the presence of metallic-like surface states. These are spin-split given its large atomic weight and spin orbit interaction[1]. Depending on the crystal termination these states behave as two dimensional (2D), delocalized states, or one dimensional (1D), localized states[2]. Such modification of the electron wavefunction is induced by the presence of step arrays, by repulsive scattering at steps and confinement within terraces[3] and has been widely explored for Shockley states in noble metals [3-5]. Semimetals have not received such a widespread attention but the investigation of this 2D to 1D transition is particularly interesting since Bi is very close to being a topological insulator and great interest has emerged in topologically guaranteed 1D surface states.

We present a study that finely explores the 2D to 1D surface states transition in Bismuth using a curved crystal (see the Fermi surfaces in Figure 1). Such special samples allow for a smooth variation of the surface orientation, which translates into a smooth variation of the step separation, i.e. the step potential barriers. The evolution of the electronic structure is investigated by state-of-the-art ARPES and correlated to the local structure obtained from STM and LEED. We find that unreconstructed single bilayer height terraces stabilize these one-dimensional states. Moreover, we observed the existence of coherent 1D edge states which are delocalized across the terrace length in spite of the absence of topological protection. They hold similar characteristics of quantum spin hall states and can help realizing electronic transport via edge channels, essential for future spintronic devices.

*Acknowledgements: MINECO MAT2016-78293-C6; EFA 194/16 (TNSI, (FEDER, EU).*

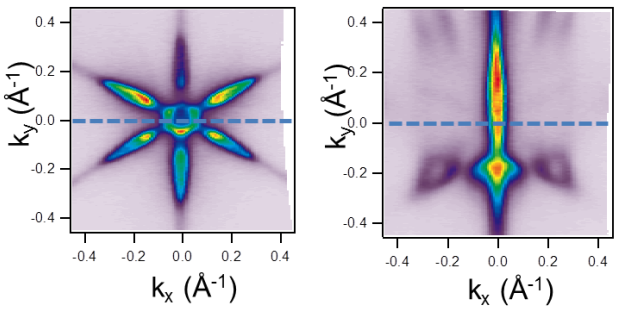


*Figure 1. Transformation of the Bi(111) surface states at the Fermi energy from the flat surface (left) to a highly-stepped one (right). The electronic character varies from being 2D to 1D. This evolution is systematically traced as function of the step density along the curvature of a curved single crystal.*

[1]Ph. Hofmann, Prog. In Surf. Sci. 81,191 (2006).
[2]J. W. Wells et al., Phys. Rev. Lett., 102, 096802 (2009).
[3]L. Bürgi et al., Phys. Rev. Lett. 81, 5370 (1998).
[4]J. E. Ortega et al., Phys. Rev. B 87, 115425 (2013).
[5]J. Lobo-Checa et al., Phys. Rev. B, 84, 245419 (2011).