# SEMINARIO
# Departamentos de Física Teórica I y II
# Universidad Complutense de Madrid

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**TITULO: Landau Levels and Edge States at the Surface of a Topological Insulator**

**LUGAR**: FACULTAD DE CIENCIAS FÍSICAS UCM
**DÍA**: 10 de junio, 2013 (Lunes)
**HORA**: 14:30
**AULA**: Seminario Depto. Física Teórica I, Planta 3ª

## ABSTRACT

A topological insulator, TI, is a material, which is gapped in the bulk but has gapless states at the surface. On strong topological insulators the electrons at the surfaces are described by a massless Dirac equation, and the band structure is a Dirac cone located at the centre of the two-dimensional Brillouin zone. A magnetic field, $B$, applied perpendicular to the surface will lead to Landau levels in the electronic spectrum and the quantum Hall effect. The Landau levels occurs at energies $E_n = \pm\sqrt{2n} v_F \ell^{-1}$ where $v_F$ is the velocity of the surface states, $\ell$ is the magnetic length and $n$=0,1,2.. Since the Hall conductivity increases by $e^2/h$ where the Fermi energy cross a Landau level, the Hall conductivity in an isolated surface of a TI is half quantized, $\sigma_{xy} = (n + 1/2)e^2/h$.

In this presentation we discuss the chiral edge states associated with the half-integer quantum Hall effect. The chiral edge states can only be integer quantized, and the conflict between the integer chiral edge states and the half-integer quantum Hall effect should be resolved by considering a slab geometry. In this configuration the top and bottom surface states should necessary talk through the chiral two-dimensional Dirac-like electron gas that reside on the perpendicular surface connecting them. We study a quantum wire along the $x$-direction, with a rectangular section. By imposing the appropriated boundary conditions we obtain the Dirac equations describing the motion of the electrons in the different planes of the wire. In presence of a magnetic field applied in the $z$-direction, electrons in the $x$-$y$ planes move in cyclotron orbits whereas electrons in the $y$-$z$ plane are not affected by the orbital magnetic field. At the interface between these planes chiral edge states appear. In this presentation we discuss the nature of these edge states, the coupling between edge states located in the top and bottom surfaces, the effect of Zeeman splitting on the edge states, the effect of a bias voltage, etc.