



The Abdus Salam
International Centre for Theoretical Physics



**FIFTH STIG LUNDQVIST CONFERENCE ON THE
ADVANCING FRONTIERS OF CONDENSED MATTER PHYSICS
11 - 15 July 2011**

**TOPOLOGICAL PHASES AND PHASE TRANSITIONS IN HONEYCOMB FERMIONIC
LATTICES: SPIN-IMBALANCED QHE, SPIN TEXTURES
AND MERGING OF DIRAC POINTS**

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ABSTRACT:

The quantum Hall effect - the exact quantization of the transverse Hall conductivity- finds its roots in time-reversal breaking perturbations. Indeed, a magnetic field can produce chiral edge states, which transport current without dissipation. Recently, the realm of quantum Hall physics has revealed novel quantum phases, with the discovery of the quantum spin Hall effect. The latter was observed in materials with important spin-orbit interactions and leads to finite spin-conductivity. This intrinsic spin-orbit interaction acts as equal but opposite magnetic fields on each spin component and produces counter-propagating edge states with opposite spins. In the first part of this talk, we reveal new topological phases that arise when the effects produced by spin-orbit couplings and magnetic fields are combined. We demonstrate that this system provides an elegant setup to generate spin- and charge-edge currents, which are chiral, and hence robust against scattering. In addition, we show that the Rashba spin-orbit interaction may lead to quantized edge currents with an unexpected spin texture. The exquisite control over these polarized current-carrying states will pave an interesting route for the development of quantum spintronics. In the last part of the talk, the merging of Dirac points in shaken honeycomb optical lattices will be discussed, as well as the corresponding topological phase transition.