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HUBBARD-MOTT PHYSICS OF ELECTRONS IN AN ARTIFICIAL SEMICONDUCTOR LATTICE

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ABSTRACT:

I'll discuss our efforts directed towards the design and exploration of novel collective electron states in controllable artificial lattice structures that are realized in semiconductor quantum heterostructures by the most advanced nanofabrication methods. The nanofabricated semiconductor systems can be regarded as a class of scalable quantum simulators of novel quantum states of electrons. These studies reveal striking interplays between fundamental electron interactions and geometrical constraints (topology). We focus in particular on the honeycomb topology, or 'artificial graphene' (AG) [1]. High quality AG supports Dirac fermions. Quantum interactions in AG are tunable by design and by external fields [2]. Dirac fermions and the emergence of quantum phases, such as spin liquids and topologically protected states, can be studied by highly demanding inelastic light scattering methods and by electrical transport at low temperatures. In our most recent studies [3] we probed the excitation spectrum of electrons in the honeycomb lattice in a magnetic field identifying collective modes that emerged from the Coulomb interaction in the artificial lattice, as predicted by the Mott-Hubbard model [4]. These observations allow us to determine the Hubbard gap and suggest the existence of a Coulomb-driven ground state [3]. The proposed research promises to further expand current realms of study of quantum simulators. While the experiments are challenging, studies of electrons confined to artificial lattices should provide key perspectives on strong electron correlation in condensed matter science.

* work done in collaboration with A. Singha, M. Gibertini, M. Polini, B. Karmakar, M. Katsnelson, S. Yuan, A. Pinczuk, G. Vignale, L.N. Pfeiffer, K.W. West

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