Electronic structure of multilayer graphene[1]

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The single-particle low-energy Hamiltonian of bilayer graphene describes chiral quasiparticles with a dominantly parabolic dispersion exhibiting Berry phase 2π. This chiral Hamiltonian produces a doubly-degenerate zero-energy Landau level incorporating two different orbital states with the same energy. Taking into account spin and valley degeneracies, the zero-energy Landau level in a bilayer is eightfold degenerate, as compared to the fourfold degeneracy of other bilayer states and the fourfold degeneracy of all levels in a monolayer. Such levels can be split by interlayer asymmetry, due to the presence of an external gate or doping, or by interaction effects. This talk will describe the electronic behavior of multilayer graphene, focusing on three, four and five layers. The goal will be to identify features that are distinct from those observed in monolayers and bilayers, and to highlight effects - such as level splitting and crossing - that can be explained either within the single-particle picture or that require an understanding of electronic interactions. For example, the low-energy Hamiltonian of ABA-stacked multilayer graphene may be partially diagonalized into an approximate block-diagonal form, with each diagonal block contributing parabolic bands except for an additional block describing Dirac-like bands with a linear dispersion in a multilayer with an odd number of layers. By taking into account the symmetry of the crystal structure, it is possible to fully include the band parameters and to analyze their effect on the block-diagonal Hamiltonian. Next-nearest-layer couplings are shown to be particularly important in determining the low-energy spectrum and the phase diagram of the quantum Hall conductivity by causing energy shifts, level anti-crossings, and valley splitting of the low-lying Landau levels.