Charge-Doping a Mott Insulator via Graphene Heterostructures

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a-$RuCl_3$ is a layered antiferromagnetic Mott insulator recently found to host a Kitaev quantum spin liquid, and notably there has been a claim for non-Abelian transport seen in a quantized thermal Hall conductance experiment. Seeking a means to access this physics using electronic approaches, we have begun exploring this material by exfoliation a la graphene to make meso-scale devices. In particular we have incorporated $RuCl_3$ flakes into so-called van der Waals heterostructures. While the electrical conductivity of $RuCl_3$ alone is seen to drop like a rock with decreasing temperature, when placed in close proximity to monolayer graphene we observe an anomalously high conductivity through the combined system. Moreover we find evidence of multiband transport and clear signatures of a 'critical resistivity' due to electron scattering by spin fluctuations near a magnetic phase transition. All of these effects vary with an applied gate voltage. It appears that proximity to graphene induces a charge transfer to $RuCl_3$ that is sensitive to and perhaps controllable by an external voltage.