

MAR17-2016-001773

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Iridates and RuCl_3 - from Heisenberg antiferromagnets to potential Kitaev spin-liquids¹

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The observed richness of topological states on the single-electron level prompts the question what kind of topological phases can develop in more strongly correlated, many-body electron systems. Correlation effects, in particular intra- and inter-orbital electron-electron interactions, are very substantial in $3d$ transition-metal compounds such as the copper oxides, but the spin-orbit coupling (SOC) is weak. In $5d$ transition-metal compounds such as iridates, the interesting situation arises that the SOC and Coulomb interactions meet on the same energy scale. The electronic structure of iridates thus depends on a strong competition between the electronic hopping amplitudes, local energy-level splittings, electron-electron interaction strengths, and the SOC of the Ir $5d$ electrons. The interplay of these ingredients offers the potential to stabilise relatively well-understood states such as a 2D Heisenberg-like antiferromagnet in Sr_2IrO_4 , but in principle also far more exotic ones, such a topological Kitaev quantum spin liquid, in (hyper)honeycomb iridates. I will discuss the microscopic electronic structures of these iridates, their proximity to idealized Heisenberg and Kitaev models and our contributions to establishing the physical factors that appear to have preempted the realization of quantum spin liquid phases so far and include a discussion on the $4d$ transition metal chloride RuCl_3 .

¹Supported by SFB 1143 of the Deutsche Forschungsgemeinschaft