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SUPPLEMENTAL MATERIAL

Spin-orbit coupling

The spin-orbit coupling acts as an on-site term, $H_{\rm SOC} = 2\eta \sum_i \mathbf{L}_i \cdot \mathbf{S}_i$, where the sum is over the Ru sites. The crystal field splits the five Ru d orbitals in the e_g doublet and the t_{2g} triplet but only the t_{2g} orbitals are relevant close to the Fermi level. These three orbitals behave like a $l = 1$ angular momentum representation. Once expressed in terms of these orbitals only, the spin-orbit coupling Hamiltonian becomes [37, 38]

$$H_{\rm SOC} = i\eta \sum_{\mathbf{k}} \sum_{l,m,n} \epsilon_{lmn} \sum_{s,s'} \sigma^n_{ss'} c^\dagger_{\mathbf{k}ls} c_{\mathbf{k}ms'}$$

where l, m, n are orbital indices, s, s' are spin indices and σ^n is the n-th Pauli matrix. The orbital indices are defined in the following way: $l = 1, 2, 3$ for, respectively, the orbital d_{yz} (B), d_{zx} (A) and d_{xy} (C).

Interaction parameters

In Table I, we give different estimates of the interaction parameters used in the main text (U, U' and J) that can be found in the literature. In Refs. [60] and [61], a constrained random phase approximation (cRPA) calculation was performed to estimate these parameters. These two references give consistent results and an estimate for J/U of 0.1. In Ref. [62], an RG calculation performed in the one-dimensional limit of the d_{zx} and d_{yz} orbitals lead to the right prediction for the crossover to 3D Fermi liquid behaviour in Sr_2RuO_4 ($T_{3D} \simeq 60K$). A value of 2.2 eV was taken for U and the relevant parameter range for J was considered to be between 0.13 and 0.4 eV. This corresponds to a value of J/U between 0.059 and 0.18. These estimates are in fair agreement with the range of J/U for which our calculation is in agreement with the measured critical specific heat jump, which is roughly given by $0.05 < J/U < 0.065$ and $0.075 < J/U < 0.085$. In Ref. [63] (see also references therein), a mean-field (MF) rotationally invariant slave bosons calculation was performed to study the impact of the Coulomb repulsion on the quasiparticle bands. From a survey of numerous references, they located U in the region 1.5-3.1 eV and J at 0.35 eV. Finally, Ref. [61] also reports a local density approximation associated with a dynamical mean field theory (LDA+DMFT) calculation. They obtain an estimate of $J = 0.4$ eV by fitting the predicted mass enhancement to the experimental value. This estimate is somewhat larger than the previous ones.

Ref.	Method	U	U'	J	J/U
[60]	cRPA	2.56	1.94	0.26	0.101
[61]	cRPA	2.3	$U-2J$	0.25	0.108
[62]	1D RG	2.2	-	0.13-0.4	0.059-0.18
[63]	MF	1.5-3.1	$U-2J$	0.35	0.11-0.23
[61]	LDA+DMFT	2.3	$U-2J$	0.4	0.17

TABLE I. Interaction parameters (in eV) obtained by various methods.

Pairing eigenvalue

In Fig. 5, we show the pairing eigenvalue λ for different pairing symmetries. The favoured state is the one with the largest value of $|\lambda|$. We show the eigenvalue for two odd-parity channels: one for the chiral state $\mathbf{d} = (p_x \pm ip_y)\hat{\mathbf{z}}$ and one for the most favoured helical state $\mathbf{d} =$