Tipping point of triplet pairing:
Evidence for even parity unconventional superconductivity in Sr$_2$RuO$_4$

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The physical picture of unconventional superconductivity (SC) in Sr$_2$RuO$_4$ has remained controversial since its discovery. While the system was considered a solid-state analogue to the superfluid $^3$He-A phase for more than two decades [1,2], the broadly discussed chiral triplet scenario has been recently overturned [3]. However, other proposed triplet-pairing states are still viable. Establishing the condensate magnetic susceptibility is crucial as it reveals a sharp distinction between even parity (singlet) and odd parity (triplet) pairing [Fig. 1(a)], since the superconducting condensate is magnetically polarizable only in the latter case.

Here we use $^{17}$O NMR spectroscopy to probe the nature of the SC state in Sr$_2$RuO$_4$ and its evolution with magnetic field. The Knight shift $K$, being sensitive to the spin polarization, is measured in the limit $T \to 0$ across the field-tuned transition down to $B/B_{c2} < 0.2$ [4]. While $K$ includes contributions of both the field-induced quasiparticles (QP) and a possible spin polarization of the condensate (of order unity for a $p$-wave state), the specific heat $C/T$ includes only the QP term. By comparing their field dependences [Fig. 1(b)], we find that the drop of $K$ in the SC state coincides with the reduction of $C/T$ – leaving no room for a finite condensate contribution. This way, we establish an upper bound for the condensate magnetic response of $< 10\%$ of the normal-state susceptibility, which is sufficient to exclude odd-parity candidates [4].


Figure 1: (a) While in most superconductors the Cooper pair spins form a singlet (top), Sr$_2$RuO$_4$ has been considered as a candidate for spin-triplet pairing (bottom) since the 1990’s [1,2]. (b) Our detailed $^{17}$O NMR studies [4] reveal that the drop of spin susceptibility (proportional to Knight shift $K$) coincides with the reduction of the specific heat $C/T$ (magenta line) in the superconducting state, implying a condensate contribution indistinguishable from zero.