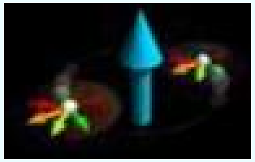

Workshop Summary: Sr_2RuO_4 and Chiral p-wave Superconductivity

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Time Reversal Symmetry Breaking

Experiment	TRSB?	Domain size [limit >0.3μ]
muSR (Luke & Ishida)	Yes	< 2 μ
Kerr rotation (Kapitulnik)	Yes	> 50 μ with field cooling ~ > 15-20 μ in ZFC
Scanning Hall Probe (Moler)	No	< 1 μ
SQUID (Kirtley)	No	< 2 μ
Tunneling (van Harlingen)	Yes	< 1 μ ~0.5 μ dynamic
Tunneling (Liu) Corner junctions	Parity Yes	>10-50 μ

Need to get a handle on domain walls (if they exist!)

Reconciling TRSB expts:

•Are the surfaces different than bulk on ~ micron scale? (still would have problems with tunneling and Kerr rotation)

•Non-BCS wave function as described by Leggett? (what about muSR? Kerr rotation?)

muSR is key probe for internal fields:

muSR signal tied to Tc is compelling evidence of internal fields. Need to learn how to extract more detailed information from muSR

• are the fields due to muons, impurities, domain walls, all or none of these? Try to control domain walls through field cooling or other methods to determine this.

• use slow muons or beta-NMR to determine fields as function of depth from surface

Kerr rotation theory?

A personal opinion on the state of play in Sr_2RuO_4

Triplet?	Almost certainly
TRSB?	Probably
Superconducting domains?	Almost certainly
Rotatable d-vector?	Less clear

Challenges

Experimental

Control domains

Establish strength of spin-orbit coupling

Precise mapping of phase diagram thermodynamics in superconducting state *and its vicinity.*

Theoretical

More holistic approach please

Establish strength of spin-orbit coupling

Preparedness to embark on phenomenological modeling as an aid to understanding of experiments

How sure are we that Sr_2RuO_4 is a spin-triplet superconductor?

Strong "direct" pieces of evidence:

1. NMR Knight shifts
 - Especially for H //ab (Sufficient H_{c2}, large GL κ, large penetration depth 3 μm)
 - On ^{101}Ru, ^{99}Ru, and ^{17}O (all sites)
 - Well-defined spin and orbital part determination from the K-χ plots
 - Simultaneous measurements of $1/T_1$: a sharp drop immediately below T_c
 - Vortex pinning is very weak. (cf. Pinning features only at low H and very near H_{c2})
 - Freq. and H are relatively low (small heating)
 - No pressure cell needed (samples directly in liquid He)
2. Polarized-neutron "Shull-Wedgewood" experiment (probes $S + L$)
3. Expts indicating Odd Parity (π-junction SQUID, Pb/SRO/Pb proximity effect, etc.)

Controversial facts against spin-triplet scenario:

1. Strong H_{c2} suppression for H //ab (for which NMR shows spins are polarizable)
 - Pauli limiting due to singlet pairing?
 - The double transition "D-phase" may be FFLO?
 - H_{c2} anisotropy neat T_c is about 50 (not sufficiently large to explain the suppression?)
2.
3.

How can the "paradox" be resolved?

1. New interpretation of the NMR results?
   But how?

AND

2. New interpretation of the polarized-neutron experiments
   More measurements at lower fields? (currently at 1 T)

3. New mechanism for the H_{c2} suppression. NEW Theory !
   (1) Orbital mechanism?
   (Cooper-pair L-instability would give negligible effects.)
   (2) Competing phase?
   (DOS remains the same at high fields. Magnetic phase?)
   (3)

4. Proposals for NEW experiments
   (1) Collective modes? By NMR, by Raman
   (2) Knight shift by μSR?
   (3)