

Klein *et al.* Reply: In our Letter [1] we demonstrated that the critical resistivity of SrRuO₃ disagrees strongly with the conventional theory [2]. Our demonstration was based on an analysis previously used to show the applicability of the conventional theory to other ferromagnetic metals such as iron [3] and nickel [4]. In the preceding Comment [5] Roussev and Millis (RM) show that $d\rho/dT$ of SrRuO₃ is consistent with the conventional theory provided several assumptions apply and a different analysis is used. In our response we reject the interpretation of RM and focus on two points which we find most questionable in their analysis: the choice of the regular term $S(t)$ and the choice of the critical temperature T_c .

The choice of $S(t)$: RM fit our data assuming a Heisenberg-like critical behavior (despite the experimental evidence for Ising symmetry) and chose a temperature-dependent regular term that optimizes the fit of the data with the conventional theory, without considering the constraints imposed by the magnetic symmetry and the asymptotic behavior of $\rho(T)$ above T_c . In our analysis we fit the temperature derivative of the magnetic contribution to the resistivity, $d\rho_m/dT$, assuming a power-law divergence based on the Ising symmetry of the magnetization. For this case, in the limit $T \gg T_c$ we expect $d\rho_m/dT$ to be vanishingly small, so we assumed the measured constant limiting value $\sim 0.5 \mu\Omega \text{ cm/K}$ to be the value of the regular (nonmagnetic) term. Small deviations from this assumption for the regular term will not bring the measured exponent of $\alpha \sim 1$ down to the predicted value of 0.1.

The choice of T_c : As it is well known to anyone in the field of critical phenomena, the extracted values of critical exponents are extremely sensitive to the exact determination of T_c . RM determined the value of T_c by optimizing the fit to the conventional predictions and in their best fit they set their T_c to be 1.35 K higher than ours. In our analysis, we paid special attention to experimentally constrain the value of T_c , using both resistivity data and magnetization measurements on the same sample. The T_c we used for analyzing the resistivity data is within the experimental error (± 0.1 K) of the T_c used in analyzing the magnetization data. Our analysis of the magnetization produced the expected universal critical exponents of the magnetic phase transition. The shift used by RM not only worsens the quality of the fit of the magnetization data but it also yields $\gamma \approx 1.2$ and $\beta \approx 0.4$ above and below T_c , correspondingly. Such exponents are consistent, if at all, with Ising-like behavior above T_c crossing over to Heisenberg behavior below T_c . This is a highly implausible scenario in view of the observed high uniaxial anisotropy which becomes *stronger* below T_c . The uni-

axial anisotropy has been experimentally detected in magnetization measurements [6], Lorentz microscopy [7], and more recently in angular dependent magnetoresistance [8].

Since our paper was published, additional transport properties of SrRuO₃, consistent with our claim that these properties are anomalous, have been reported. In particular, far infrared measurements [9] have revealed anomalies in the optical conductivity which indicate unusually strong incoherent scattering in SrRuO₃, especially near and above the magnetic phase transition.

In conclusion, while we welcome the examination of our results by RM, we find their conclusion unacceptable. RM have fitted the data with all the degrees of freedom available *except* the one parameter which provides a test for anomalous critical resistivity, the exponent α . In constraining α , RM found parameters for the regular term which are physically unjustified, and a huge arbitrary shift in T_c which leads to inconsistencies in the analysis of the magnetization data. Consequently, we maintain our original claim that $d\rho_m/dT$ in SrRuO₃ is anomalous.

L. K., M. R. B., and A. K. acknowledge support by Grant No. 97-00428/1 from the United States–Israel Binational Science Foundation (BSF), Jerusalem, Israel. J. S. D. acknowledges support by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

L. Klein,¹ J. S. Dodge,² T. H. Geballe,³
M. R. Beasley,³ and A. Kapitulnik³

¹Physics Department, Bar-Ilan University
Ramat-Gan 52900, Israel

²Materials Sciences Division
E. O. Lawrence Berkeley National Laboratory
Berkeley, California 94720

³Edward L. Ginzton Laboratories, Stanford University
Stanford, California 94305

Received 21 July 1999

PACS numbers: 72.15.Eb, 75.40.Cx, 75.50.Cc

- [1] L. Klein *et al.*, Phys. Rev. Lett. **77**, 2774 (1996).
- [2] M. E. Fisher and J. S. Langer, Phys. Rev. Lett. **20**, 665 (1968); O. Entin-Wohlman, G. Deutscher, and R. Orbach, Phys. Rev. B **11**, 219 (1975); S. Alexander, J. S. Helman, and I. Balberg, Phys. Rev. B **13**, 304 (1976).
- [3] L. W. Shacklette, Phys. Rev. B **9**, 3789 (1974).
- [4] I. Nagy and L. Pal, Phys. Rev. Lett. **24**, 894 (1970).
- [5] R. Roussev and A. J. Millis, preceding Comment, Phys. Rev. Lett. **84**, 2279 (2000).
- [6] L. Klein *et al.*, J. Phys. Condens. Matter **8**, 10111 (1996).
- [7] A. F. Marshall *et al.*, J. Appl. Phys. **85**, 4131 (1999).
- [8] L. Klein *et al.* (unpublished).
- [9] P. Kostic *et al.*, Phys. Rev. Lett. **81**, 2498 (1998).