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Transport anisotropy as a signature of electron nematicity¹

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Strong electron correlations often give rise to novel phenomena that are never found in ordinary materials. One of such phenomena is the emergence of electron nematicity (EN), which was theoretically proposed in 1998 to occur due to a combined effect of electron self-organization and quantum fluctuations. Experimentally, the EN was first discovered in 1999 in the two-dimensional electron gas (2DEG) at high Landau levels, where a clear transport anisotropy was found to grow upon lowering temperature in the mK region. In search for the signatures of the EN in cuprates, we have done extensive transport measurements of $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ (LSCO) and $\text{YBa}_2\text{Cu}_3\text{O}_y$ (YBCO) systems using high-quality single crystals. We discovered in 2001 that the in-plane resistivity anisotropy in untwinned single crystals of LSCO and YBCO in the lightly hole-doped region grows below ~ 150 K with decreasing temperature, similar to the case in 2DEG, albeit the much higher temperature scale. In those samples, the easy transport axis was apparently dictated by the orthorhombic crystal structure; however, the orthorhombicity η was only up to 1.5%, while the resistivity anisotropy was up to a factor of 3, which was obviously too large for the small η . Furthermore, the anisotropy in YBCO was found to be *enhanced* with decreasing y below ~ 6.5 despite the *decreasing* η until the crystal structure turns to tetragonal at $y \simeq 6.30$. While this result gave strong evidence for the self-organized EN in high- T_c cuprates, it was not completely conclusive because of the existence of the orthorhombicity that chooses the preferred direction; also, the lack of support from neutron scattering kept the skepticism remain. However, very recently, neutron scattering has finally found corroborating anisotropy in YBCO and convincing evidence for EN in a related oxide $\text{Sr}_3\text{Ru}_2\text{O}_7$ was obtained, which together strengthened the case for cuprates considerably.

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