A unified explanation of the Kadowaki-Woods ratio in heavy fermions, transition metal oxides, transition metals, and organic charge transfer salts

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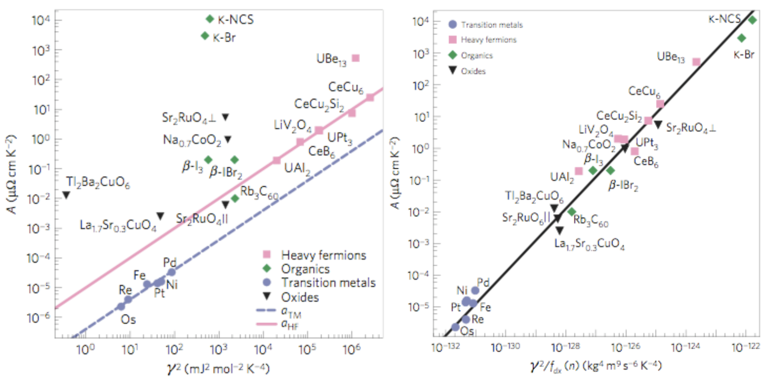
Discoveries of ratios whose values are constant within broad classes of materials have led to many deep physical insights. The Kadowaki-Woods ratio compares the temperature dependence of a metal's resistivity to that of its heat capacity; thereby probing the relationship between the electron-electron scattering rate and the renormalisation of the electron mass. However, the Kadowaki-Woods ratio takes very different values in different materials. We recently introduced a ratio, closely related to the Kadowaki-Woods ratio, that includes the effects of carrier density and spatial dimensionality and takes the same (predicted) value in organic charge transfer salts, transition metal oxides, heavy fermions and transition metals - despite the numerator and denominator varying by ten orders of magnitude [3]. Hence, in these materials, the same emergent physics is responsible for the mass enhancement and the quadratic temperature dependence of the resistivity and no exotic explanations of their Kadowaki-Woods ratios are required. Implications for theories of superconductivity in these materials will be discussed.



Left: Kadowaki-Woods plot comparing the electronic contribution to specific heat (γT) with the contribution to the resistivity from electron-electron scattering (AT^2). Right: Comparison of our theory (line) with experimental data. $f_{dx}(n)=nD_0^2\langle v_{0x}^2\rangle$, where n is the electron density, D_0 is the bare (unrenormalised) DOS at the Fermi energy and v_{0x} is the bare Fermi velocity.

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[1] A. C. Jacko, J. O. Fjaerestad & B. J. Powell, Nature Phys., advance online publication 19 April 2009 (DOI:10.1038/NPHYS1249).