Correlated states near pressure-induced instabilities

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Many complex materials display an interesting interplay between structural and electronic instabilities, which can be studied effectively under applied pressure. If a continuous structural phase transition is suppressed to low temperatures, as in the quasi-skutterudite system $(Sr/Ca)_3(Ir/Rh)_4Sn_{13}$ [1], low-energy vibrational excitations can arise that boost superconductivity and cause a linearly temperature dependent electrical resistivity. The aperiodic high-pressure host-guest structure of elemental bismuth displays a similar phenomenology [2], suggesting enhanced phonon spectral weight at low energies (Fig. 1).

It is increasingly desirable to probe the electronic structure near pressure-induced instabilities directly. We have observed the electronic Fermi surface in the correlated metallic state of a pressure-metallised Mott insulator by quantum oscillation measurements in NiS_2 [3] at pressures of up to ~120 kbar. Our results show that the Fermi surface remains large on approaching the Mott insulating state, consistent with Luttinger's theorem, whereas the quasiparticle effective mass is strongly renormalised.

[1] Goh, S. K. et al. Phys. Rev. Lett. **114,** 097002 (2015)
[2] Brown, P. et al. Science Advances **4,** eaao4793 (2018)
[3] Friedemann, S. et al. Scientific Reports **6,** 25335 (2016)

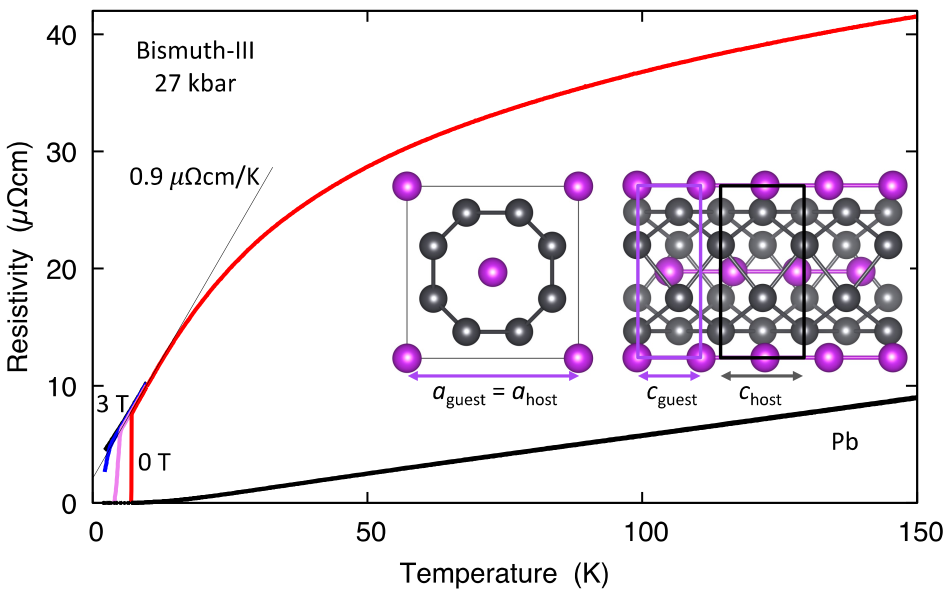

Fig. 1: Temperature dependence of the resistivity of the aperiodic high pressure structure of bismuth, Bi-III, which displays type-II superconductivity below a normal state with anomalously strong electron-phonon scattering [2]. The resistivity of the conventional strong-coupling superconductor lead, Pb, is given for comparison. The inset illustrates the aperiodic nature of Bi-III along the c-axis.