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Investigation of the Metallic State in Cubic FeGe beyond its Quantum Phase Transition

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FeGe and MnSi are prominent examples where the Dzyaloshinskii-Moriya interaction causes a modulation of the ferromagnetic structure as a consequence of the lack of inversion symmetry in the $B20$ structure (space group $P2_13$). In FeGe, helimagnetism sets in through a first order phase transition at $T_\mathrm{C} = 280\,\mathrm{K}$ with a saturated moment of $m = 1\mu_B$ per Fe atom. The helical modulation has a period of about 700 Å and propagates along the spiral propagation vector $\mathbf{k} \parallel [100]$. It alters its direction to $\mathbf{k} \parallel [111]$ at $T_2 \approx 211 - 245\,\mathrm{K}$ without a change in the period. In MnSi, however, the helical order occurs below $T_\mathrm{C} = 29\,\mathrm{K}$. The modulation has a wavelength of 175 Å and the ordered moments of about $m = 0.4\,\mu_B$ per Mn atom are perpendicular to $\mathbf{k} \parallel [111]$. It is well established that the second order phase transition is driven first order for a sufficiently weak magnetic interaction close to the critical pressure, $p_\mathrm{c} = 1.46\,\mathrm{GPa}$. In light of these structural and magnetic similarities between FeGe and MnSi, a volume compression in FeGe could tune its T_C to zero temperature with the chance to reveal peculiar electronic ground state properties at the verge of the magnetic order. Indeed, the electrical resistivity measurements, $\rho(T)$, show a suppression of the helical order at $p_c \approx 19\,\mathrm{GPa}$. The strong deviations from a Fermi-liquid behavior in a wide pressure range above p_c suggest that the suppression of T_C disagrees with the standard notion of a quantum critical phase transition. Our band-structure calculations suggest that disorder due to zero-point motion is strong enough to close the narrow gap expected for compressed FeGe, stabilizing a new magnetic ground state above p_c. An anomaly observed at T_X in the $\rho(T)$ curves recorded above p_c might be related to this magnetic phase. The isothermal structural data at low temperature revealed a discontinuous change in the pressure dependence of the shortest Fe-Ge interatomic distance close to the $T_C(p)$ phase line. The (T, V) phase diagram will be discussed and the connection with MnSi and the semiconducting properties of FeSi will be addressed.