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Intimate link between Charge Density Wave, Pseudogap and Superconducting Energy Scales in Cuprates

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The cuprate high temperature superconductors develop spontaneous charge density wave (CDW) order below a temperature $T_{\rm CDW}$ and over a wide range of hole doping (p). An outstanding challenge in the field is to understand whether this modulated phase is related to the more exhaustively studied pseudogap and superconducting phases. To address this issue, it is important to extract the energy scale $\Delta_{\rm CDW}$ associated with the CDW order, and to compare it with the pseudogap (PG) $\Delta_{\rm PG}$ and with the superconducting gap $\Delta_{\rm SC}$. However, while $T_{\rm CDW}$ is well-characterized from earlier work, little is known about $\Delta_{\rm CDW}$ until now. Here, we report the extraction of $\Delta_{\rm CDW}$ for several cuprates using electronic Raman spectroscopy. Crucially, we find that upon approaching the parent Mott state by lowering p, $\Delta_{\rm CDW}$ increases in a manner similar to the doping dependence of $\Delta_{\rm PG}$ and $\Delta_{\rm SC}$. This reveals that the above three phases have a common microscopic origin.In addition, we find that $\Delta_{\rm CDW} \approx \Delta_{\rm SC}$ over a substantial doping range, which suggests that CDW and superconducting phases are intimately related, for example intertwined or connected by an emergent symmetry.

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Summary

Topic

1. Excitations of strongly correlated electron systems

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