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Visualizing Critical Correlations Near the Metal-Insulator Transition in $Ga_{1-x}Mn_xAs$

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Semiconductors have long been an ideal class of materials for studying the metal-insulator transition. Samples of the dilute magnetic semiconductor $Ga_{1-x}Mn_xAs$ with Mn doping levels near to the metal-insulator transition have been studied using low temperature cross-sectional scanning tunneling microscopy (STM). This allows us to visualize the electronic states near the Fermi level which display unique critical properties. Strong modifications to the density of states around the Fermi energy due to electron-electron interactions are observed. In this energy range, the electronic states show a diverging correlation length approaching E_F, where the correction to the density of states due to interactions is strongest. The distance dependence of the correlations at E_F is consistent with a power law decay, expected for multifractal states near criticality in the metal-insulator transition, while away from E_F the correlations fall off exponentially. These results highlight the importance of electron-electron interactions and represent some of the first experimental observations of states near the Mott-Anderson metal-insulator transition, where both disorder and interactions are important for the localization of electronic states.

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