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Imaging ultrafast electronic order fluctuations of Fe_3O_4

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Speckle patterns manifesting from the interaction of coherent light with matter offer a glimpse into the dynamics of nanoscale domains that underpin many emergent phenomena in quantum materials. While the dynamics of the average structure can be followed with time-resolved X-ray diffraction, the ultrafast evolution of local structures and nonequilibrium conditions have thus far eluded detection due to experimental limitations, such as insufficient coherent flux. Here we demonstrate the experimental realization of a nonequilibrium X-ray speckle visibility experiment using a so-called split-and-delay setup. Photoinduced electronic domain fluctuations of the magnetic model material Fe_3O_4 reveal changes of the trimeron network configuration due to charge dynamics, offering a unique perspective on the ultrafast dynamics of the lattice structure and electronic heterogeneities.