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Momentum Signatures of Site Percolation in disordered 2D Ferromagnets in low and high defect density regimes

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As real devices necessarily contain defects, it is of interest to study wave propagation in disordered systems. In this work, we start from a 2D square lattice of magnetic spins with nearest-neighbour interactions and replace a fixed proportion of magnetic sites with nonmagnetic defects ('Site Percolation Model'). We are primarily interested in the disorder-averaged momentum signatures that occur at low and high defect densities when an initial spin wave with fixed momentum propagates through the disordered system.

At low defect densities, the system consists of a single percolating cluster with some small disconnected clusters. In this regime, we expect that the usual predictions of Anderson localization [1] should apply. Indeed, we observe two peaks in the momentum distribution: A Coherent Forward Scattering (CFS) peak in the same direction as the initial plane wave, as well as a Coherent Backward Scattering (CBS). These phenomena are consistent with existing literature on the momentum signatures of Anderson Localization in random disorder [2-3].

At high defect densities, we move into uncharted territory. In this regime, we observe that the system increasingly breaks down into multiple disconnected clusters. The formation of these disconnected clusters gives rise to a unique momentum signature in the form of oscillations in the CFS peak. These oscillations occur at frequencies consistent with the energies of the clusters and provide a unique momentum signature of cluster formation due to defects in magnetic systems.

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Position

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