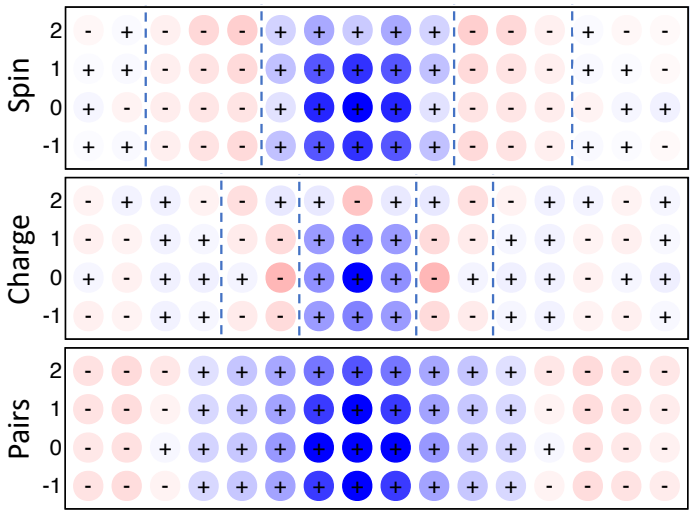
Intertwined Spin, Charge and Pair Density Wave Correlations in the Hubbard Model



Static, real-space staggered spin (top), charge (middle) and *d*-wave projected pair (bottom) correlations in the 20% hole doped two-dimensional Hubbard model calculated in a 16x4-site cluster. All correlation functions display "striped" unidirectional modulations with different periodicities but similar model parameter dependence, demonstrating their close connection.

P. Mai, S. Karakuzu, G. Balduzzi, S. Johnston, T. A. Maier, Intertwined spin, charge and pair correlations in the two-dimensional Hubbard model in the thermodynamic limit, *PNAS* **119**, 7 (2021).

Scientific Achievement

Large-scale numerical calculations reveal fluctuating spin and charge stripes intertwined with pair-density-wave correlations in the doped Hubbard model.

Significance and Impact

Results demonstrate that striped spin and charge density wave states survive in the Hubbard model in the thermodynamic limit and show how they affect the model's superconducting behavior.

Research Details

- Large-scale dynamic cluster and determinantal quantum Monte Carlo simulations were carried out for a Hubbard model, a minimal model of correlated electron materials, for different model parameters and analyzed for stripe behavior.
- Results show that strong spin and charge stripes can coexist with superconducting correlations within a single numerical solution of the Hubbard model and thus resolve a decade-long conflict in conclusions drawn from different solutions.

Work was performed at Oak Ridge National Laboratory.

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