Interplay of Frustration and Geometry in Josephson Arrays on a Dice Lattice

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Very sensitive magnetoimpedance $[Z(B)]$ measurements performed on arrays of SNS Josephson junctions with the S-islands sitting on the sites of a dice lattice reveal unusual features resulting from the interplay between the applied transverse magnetic field $B$, which frustrates the system, and the unconventional lattice geometry. The inverse magnetoinductance $L^{-1}(f) = \omega/\text{Im}Z(f)$ (where $f$ is the magnetic flux per rhombic tile in units of the flux quantum) is found to exhibit prominent peaks at $f = 1/3$ and $f = 1/6$ (and weaker maxima also at $f = 1/9$ and $f = 1/12$) reflecting the existence of ground states with a high degree of superconducting phase coherence, while the deep minimum at $f = 1/2$ points to a ground state whose phase coherence is extremely vulnerable. Within the framework of the frustrated $XY$ model, all these ground states turn out to exhibit an accidental degeneracy associated with the formation zero-energy domain walls. It is shown that, in a real array, the inclusion of magnetic interactions between currents is the most important mechanism lifting the degeneracy and stabilizing an ordered vortex pattern at low temperatures. For $f = 1/2$, however, no evidence for a phase transition is found in our finite-frequency experiments. For $f = 1/3$, despite the fact that within the $XY$ description the accidental degeneracy is so developed that, in contrast to the $f = 1/2$ case, no vortex ordering is expected down to $T = 0$, the analysis of the data support the idea of a phase transition driven by the unbinding of half-vortex pairs.

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