Supporting Information

Reconfigurable pinwheel artificial-spin-ice and superconductor hybrid device

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Calculation of vertex density and first matching field B_0:

Superconducting vortices are quantized magnetic flux, each contains a flux quantum of Φ_0=2.0×10^{-15} Wb. At a vortex density n, the total flux in a given area A is Φ_{total} = (n×A)×Φ_0, where (n×A) is the total number of vortices in area A. Since Φ_{total} = B×A, the vortex density n is directly proportional to the applied magnetic field B. Thus, the vortex density can be easily obtained by $n = B/\Phi_0$. In this experiment, one square unit with a lattice constant l = 500 nm in the pinwheel artificial spin ice contains two nanomagnets. When (n×A) = 2 with $A = l^2$, two vortices exist in each square unit, i.e. the number of nanomagnets and vortices are equal. This corresponds to the first matching field B_0=2×Φ_0/l^2≈166 Oe, at which the density of vortices equals that of nanomagnets. This calculated value is consistent with our experimental result very well.

Figure S1. MD simulations of the distribution of vortices. (a) and (b) Distributions of vortices at B=0.5B_0 and B=B_0, respectively. Black dots represent vortices. Blue and red circles are attractive and repulsive potential centers, respectively.

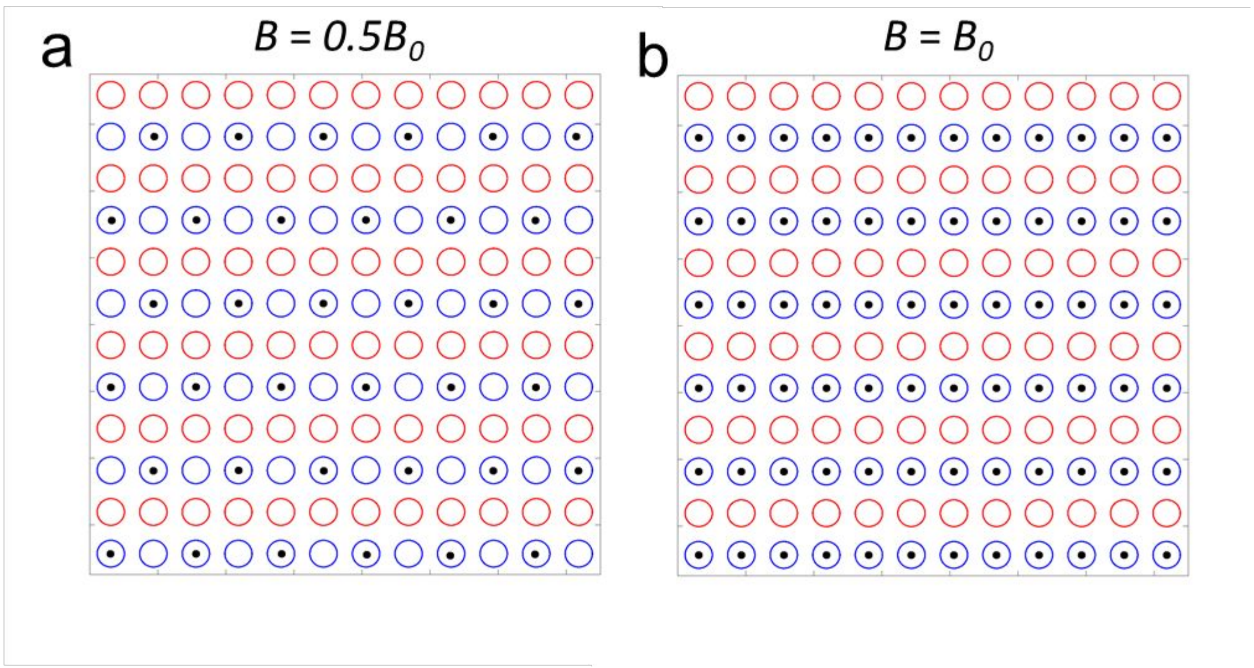
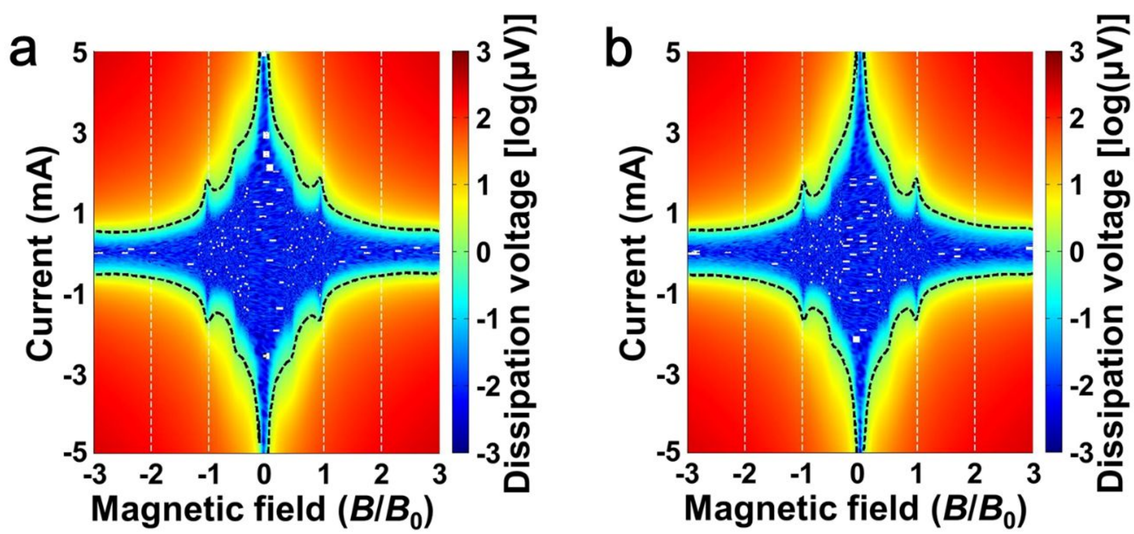


Figure S2. Longitudinal voltages for Section B. (a) and (b) Magnetic field and current dependences of the longitudinal voltages corresponding to the magnetic charge configurations shown in Figures 2c and 2d, respectively. The color scale is for the values of the $\log|V|$. The black dashed lines indicate the critical currents defined by a voltage criterion of 1 μV. The magnetic field is in units of B_0=165.6 Oe, corresponding to one vortex per nanomagnet.



Video 1. Results of MD simulations for vortex motion in Section A at B=0.5B_0. Black dots represent vortices. Blue and red spots represent attractive and repulsive potential centers, respectively. The current induced driving force is up in both panels.

Video 2. Results of MD simulations for vortex motion in Section A at B=2B_0. Black dots represent vortices. Blue and red spots represent attractive and repulsive potential centers, respectively. The current induced driving force is up in both panels.

Video 3. Results of MD simulations for vortex motion in Section B at B=0.5B_0. Black dots represent vortices. Blue and red spots represent attractive and repulsive potential centers, respectively. The current induced driving force is up in both panels.

Video 4. Results of MD simulations for vortex motion in Section B at B=2B_0. Black dots represent vortices. Blue and red spots represent attractive and repulsive potential centers, respectively. The current induced driving force is up in both panels.