

Topological Defects in the Non-Reciprocal XY Model

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Non-reciprocal interactions are fundamental for crowd dynamics and animal flocking collective phenomena, where limited vision cones result in influences that are not necessarily mutual. To study the consequences of non-reciprocity, in particular on topological defects, we propose a new generic framework based on the 2D XY model.

At equilibrium, the actual shape of a defect (whether it is a source, a sink or a vortex for instance) is rather irrelevant as its charge q alone faithfully describes its behaviour. Here, we demonstrate that for a system with non-reciprocal interactions, the shape μ of a defect becomes crucial for its dynamics in the xy -plane. While in the critical phase of XY Model, pairs of defects always attract, defects in the non-reciprocal XY model exhibit shape-dependent complex motion patterns, including rapid annihilation or prolonged stabilization, challenging the Kosterlitz-Thouless scenario and paving the way to a refined control on topological structures.

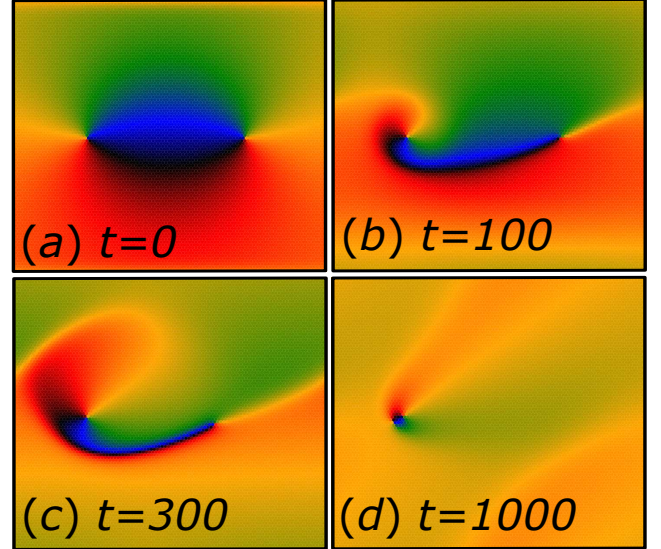


Fig. 2. Some shape combinations lead to new defect pair interactions, far from the classical XY scenario. Here four snapshots over time of a 200×200 spin system. Same cyclic colorcode as in Fig. 1 for the phase θ of individual spins.

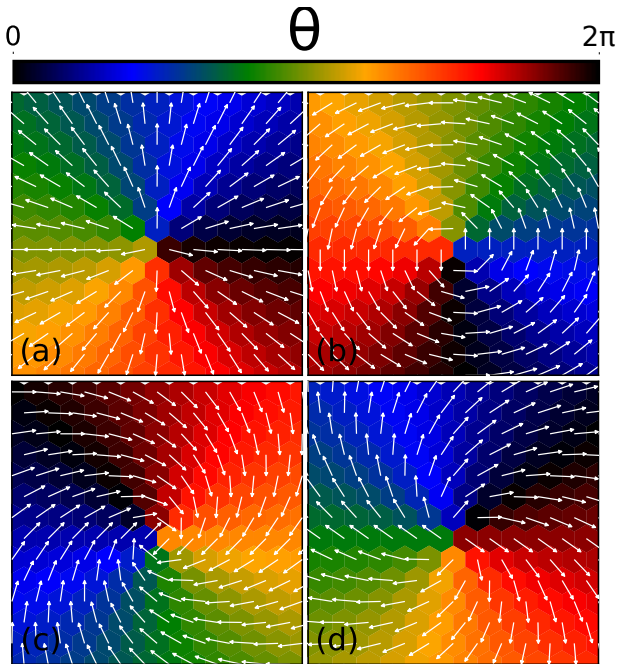


Fig. 1. Four defects with identical $q = +1$ topological charge but with different shapes $\mu_+ = 0, \pi/2, 4, 5.6$ from (a) to (d).