THE CDW – SC COMPETITION AS A SOURCE OF FILAMENTARY SUPERCONDUCTIVITY: A MONTE CARLO STUDY

G. Venditti[1], M. Grilli[2], S. Caprara[2] and J. Lorenzana[3]

[1] Institute for superconductors, oxides and other innovative materials (SPIN-CNR), Area della Ricerca di Tor Vergata, Via del Fosso del Cavaliere 100, 00133 Rome, Italy

[2] Dipartimento di Fisica, Università di Roma "La Sapienza", P.e Aldo Moro, 5, 00185 Rome, Italy

[3] Institute for Complex Systems (ISC), Consiglio Nazionale delle Ricerche, Dipartimento di Fisica, Universit`a di Roma "La Sapienza", 00185 Rome, Italy

The competition of different phases is a phenomenon encountered in many physical systems and it has often interesting implications. As solid ^4He may acquire superfluid characteristics due to the frustration of the solid phase at grain boundaries [1] or the coexistence of FM and AF clusters in manganites may have "pseudo-gap" characteristics [2], the competition between charge ordering and superconductivity (CO-SC) can generate filamentary superconductivity [3]. This is supported by recent magnetoresistance experiments on $La_{2-x}Sr_xCuO_4$ thin films [4], where it was also pointed out the importance of disorder in the formation of the filamentary superconducting phase.

In this work, we studied the CO-SC competition by means of Monte Carlo numerical simulations, observing how it is reflected in many physical quantities as a function of temperature. We use an anisotropic Heisenberg model on a two-dimensional square lattice that captures the basic symmetries of the problem: the out-of-plane component of the pseudospin s^z encodes two possible CDW variants (up/down) and the in-plane component stands for the superconducting order parameter. We construct a phase diagram where the anisotropy term introduced plays the same role as the magnetic field in real experiments and it can tune continuously the transition from the topological BKT to the CDW state (see Figure 1). Importantly, we find the presence of impurities is necessary in order to stabilize the clustering of polycrystalline charge ordered domains and the appearance of filamentary superconductivity.

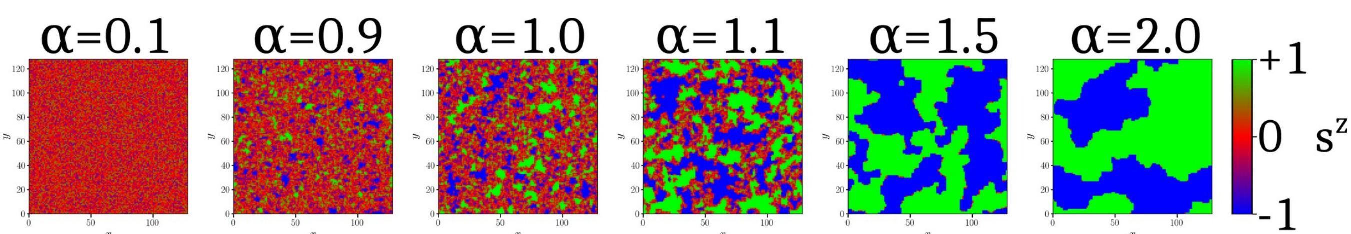

Figure 1: Snapshots of the final configurations of spin at *T=0.001* for *L=128.* The color maps the out-of-plane component from up ($s^z=+1$ in green), to in-plane ($s^z=0$ in red), to down ($s^z=-1$ in blue).

[1] L. Pollet et al. *Phys. Rev. Lett.* ***98****, 135301 (2007).*
[2] E. Dagotto et al. *Physics Reports* ***344****, 1-153 (2001).*
[3] B. Leridon et al. *New J. Phys.* ***22*** *073025 (2020).*
[4] S. Caprara et al. *SciPost Phys.* ***8****, 003 (2020).*