A Γ-convergence result for 2D type-I superconductors

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In the Ginzburg-Landau model superconductors are characterized by a parameter κ called the Ginzburg-Landau parameter. If $\kappa < \frac{1}{\sqrt{2}}$ the superconductors are classified as type-I, if $\kappa > \frac{1}{\sqrt{2}}$ they are classified as type-II. While in type-II superconductors vortices appear, in type-I superconductors normal and superconducting regions are formed, separated by interfaces. In particular by the Meissner Effect, if ρ is the density of superconducting electrons and B is the magnetic field, it is observed that $\rho B \simeq 0$. Considering a 3D sample, it is experimentally observed that complex patterns appear at the surface. It is believed that these patterns are a manifestation of branching patterns inside the sample. In [2] two regimes of parameters for the 3D type-I model are derived, corresponding to uniform and non uniform branching patterns. Moreover, in [1] a Γ-convergence result is proved for the full 3D model in the case of uniform branching patterns. In this talk I present a Γ-convergence result for the 2D type-I Ginzburg-Landau model in the crossover of the two regimes found in [2]. This is a first step in understanding how to extend the results of [1] to the second regime. With these hypothesis on the parameters the energy functional shares similarities with a Modica-Mortola type functional and in the limit Γ-converges to the area functional. To prove this result, it is necessary to carefully treat the global interaction between the phase of the complex order parameter u and the vector potential A, taking into account the gauge invariance satisfied by the functional. This talk is based on an ongoing work with Michael Goldman and Alessandro Zilio.

[1] S. Conti, M. Goldman, F. Otto, and S. Serfaty, *A branched transport limit of the Ginzburg-Landau functional*, J. Éc. polytech. Math. **5** (2018), 317–375.

[2] S. Conti, F. Otto, and S. Serfaty, *Branched microstructures in the Ginzburg-Landau model of type-I superconductors*, SIAM J. Math. Anal. **48** (2016), no. 4, 2994–3034.