The first order approach applied to 2D constrained superconductors: a general solution

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The Ginzburg-Landau theory published in 1950 was able to describe the superconducting to normal transition of the known materials at that time but also allowed the prediction of many unknown phenomena, as the type I and II prediction by Abrikosov in 1957. The simplicity of the GL functional is the responsible for so broad applicability of the theory in different domains of science. Naturally, the techniques used to solve the GL theory also receive a broad attention from the scientific community because a simpler or more accurate procedure may be applied in one of those field mentioned before. The first order equation is a mathematical approach to transform the set of second order differential equations that describe the superconducting state into a single first order differential equation. The basic idea behind this approach can be pictorially compared with the algebraic operator method to solve the quantum oscillator. The second order Schrödinger equation is replaced by $\hat{a}_{+}\psi = 0$. In the latter equation, the physical concept is that we cannot go bellow the ground state. So, in this paper we present a solution to the Ginzburg-Landau equations for a disc in presence of an applied field ranging from 0 till $H_{c2}$. As it will be shown later, the system geometry does not need to be flat or regular and the applied field does not need to be homogeneous neither. The general requirement of the first order approach opens the windows of applicability of the GL theory to many other system since the problem of finding a solution will be simplified to a numerical integration of an algebraic function.