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# Unravelling the magnetic properties of $\text{Fe}_{0.5}\text{TeSe}_{0.5}$ superconductor using Ginzburg–Landau (GL) formulation

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## Abstract

The Gibbs free energy of the magnetic superconductor  $\text{FeTe}_{0.5}\text{Se}_{0.5}$  has been analyzed in conjunction with the Werthamer–Helfand–Hohenberg (WHH) equation at a critical temperature ( $T_c$ ) of 12 K. This study presents the temperature dependence of the upper critical magnetic field ( $H_{c2}$ ), coherence length ( $\xi_{GL}$ ), penetration depth ( $\lambda_{GL}$ ), and critical current density ( $J_c$ ) of the  $\text{FeTe}_{0.5}\text{Se}_{0.5}$  superconductor. Using experimentally obtained values, phase diagrams were constructed, showing that  $H_{c2}$ ,  $\xi_{GL}$ ,  $\lambda_{GL}$ , and  $J_c$  exhibit non-linear temperature dependence and approach zero as  $T$  approaches  $T_c$ . The large values of the Ginzburg–Landau (GL) characteristic parameters indicate that  $\text{FeTe}_{0.5}\text{Se}_{0.5}$  is a strongly type-II superconductor. The results obtained in this work are in good agreement with previous experimental findings on  $\text{FeTe}_{0.5}\text{Se}_{0.5}$  superconductor.

**Keywords** Iron based superconductors (IBS), Upper critical field, Coherence length, Penetration depth and critical current density

## 1 Introduction

Superconductivity and magnetism deemed to be poles apart as magnetic fields typically destroy superconducting state are now studied together in many cases. The discovery of  $\text{LaFeAsO}_{1-x}\text{F}_x$ , exhibiting a superconducting transition temperature of up to 26 K uniquely combines magnetic iron with superconductivity, thus inviting a significant scientific attention [1]. The highest superconducting transition temperature ( $T_c$ ) measured at ambient pressure in bulk iron based superconductors (IBS) is 43 K which is higher than that of some cuprates, such as optionally doped  $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$  [2]. Different phases of iron-based superconductors are discovered which include  $\text{Ba}_{1-x}\text{K}_x\text{Fe}_2\text{As}$ , the “122-phase” with  $T_c$  of ~38 K,  $\text{Li}_{1-x}\text{FeAs}$ , so-called “111-phase” with  $T_c = 18$  K and  $\text{FeSe}$ , so-called “11-phase” with  $T_c = 8$  K [3–5]. The superconducting transition temperature has increased up to ~55 K by replacing or substituting/doping of La with other rare earth elements such as, Ce, Sm, Nd, Pr, Gd, Eu and Tm wherein the obtained phase is called “1111-phase” These discoveries have greatly advanced the field of superconductors,



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