# DECLARATION

**Declaration by Candidate**

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# DEDICATION

To my wife Carolyne, Daughters Hope, Blessings and Noela who stood by me in prayers and encouragement even in my absence.

# ABSTRACT

High temperature superconductivity mechanism has remained an elusive concept for a long time. Field dependence of the properties of high temperature superconductors could be on the brink of solving this puzzle. This Study shows that there is a strong field dependence on the theory of high temperature superconductors (HTSCs). High temperature superconductors of transition temperature, $T_c > 77\ K$ (boiling point of liquid nitrogen) were studied. This research established that there are effects of applied magnetic field on a two dimensional square lattice, effective magnetic flux per plaquette and electric field on oscillating Cooper pairs parallel to copper oxide planes, and their effects on the thermodynamic properties of HTSCs. Second quantization formalism was used in determining the thermodynamic properties of HTSCs such as the energy gap and transition temperature. The effect of electric field $E$ on an oscillating Cooper pair along the $CuO_2$plane was found to give the value of Δ = 62.5 meV. The ratio ($\alpha$) of flux through the lattice cell to one flux quantum indicates that there is no Meissner expulsion of flux as the applied magnetic field $H$ increases through the lattice cell. The value of $T_c$ at which superconductivity disappears was found to be 177$K$ for YBCO/BSCCO systems. The lattice spacing $a$ at 300$K$was 2.3Å. The value of $\alpha$ was2.28 x $10^{-7}$ when $H_{c_2}$ = 3.0 x $10^6$G and $a$ = 3Å.Studies on the effect of effective magnetic flux per plaquette Φ established that increase in values of Φ leads to increase in values of$T_c$ and forΦ = 5.84$G/m^2$, $T_c$ = 300$K$.

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# LIST OF SYMBOLS AND ABBREVIATIONS

$T_c$ -Transition Temperature

**B** -Magnetic Induction

H - Magnetic Field

$\mu$ - Magnetic Permeability in a Medium

T - Temperature

$H_c$ -Critical Magnetic Field

BCS - Berdeen, Cooper and Schrieffer

YBCO -Yttrium Barium Cooper Oxide

$B_{c_2}$ - Upper Critical Magnetic Induction

Tl2212 - Thallium based HTSC

Bi2212 - Barium based HTSC

$B_{c_1}$ - Lower Critical Magnetic Induction

$\mu_0$ - Magnetic Permeability in Free Space (Vacuum)

$H_{c_2}$ - Upper Critical Magnetic Field

$H_{c_1}$ - Lower Critical Magnetic Field

$CeCu_2$Si - Cerium Copper Silicon

$UBe_{13}$ - Uranium Beryllium

$UPt_3$ - Uranium Platinum

TMTSF - Tetra Methyl tetra Selena Valene

BEDT-TTF - Bis-ethylene Dithiotetra thia ful Valene

$La_{2-x}Ba_xCuO_4$ - Lanthanum Barium Copper Oxide

Bi-Sr-Cu-O - Bismuth Strontium Copper Oxide

Tl-Ba-Ca-Cu-O - Thallium Barium Calcium Copper Oxide

Hg-Ba-Ca-Cu-O - Mercury Barium Calcium Copper Oxide

$La_{2-x}Ce_xCuO_{4+y}$- Lanthanum Cerium Copper Oxide

HTSCs- High Temperature Superconductors

$CuO_2$ - Copper Oxide

$LiTi_2O_4$ - Lithium Titanium Oxide

SrTi$O_{3-x}$ - Strontium Titanium Oxide

BaP$b_{1-x}Bi_xO_3$- Barium Lead Bismuth Oxide

Babi$O_3$ - Barium Bismuth Oxide

$YBa_2Cu_3O_{7-x}$- Yttrium Barium Copper Oxide

Cu-O - Copper Oxide

$T_c$s - Transition Temperatures

$Nd_{2-x}Ce_xCuO_4$- Neodymium Cerium Copper Oxide

BSCCO - Barium Strontium Calcium Copper Oxide

ħ $=\frac{h}{2\pi}$

$k_B$ - Boltzmann Constant

$\xi$ - Coherence Length

$\kappa=\frac{\lambda}{\xi}$ - Ginzburg-Landau parameter

Δ - Energy gap

$\lambda$ - Penetration Depth

$\xi_{ab}$ - Coherence length in ab Plane

$\xi_c$ - Coherence length along c-axis

$\Phi_0$ - Flux Quantum

| | |
|---|---|
| $k_{el}$ | - Electronic Heat Transport |
| $k_{lat}$ | - Lattice Heat Transport |
| $\Delta(0)$ | - Energy Gap at T=0 |
| $m_c$ | - Effective Mass in c-axis |
| $m_{ab}$ | - Effective Mass in ab Plane |
| $\gamma_a$ | - Anisotropy Parameter |
| $\lambda_{ab}$ | - Penetration Depth in ab Plane |
| $\lambda_c$ | - Penetration Depth in c-axis |
| $H_{c1}$ | - Lower Critical Magnetic Field |
| Hc(T) | - Critical Magnetic Field at Any Temperature |
| $H_c$(O) | - Critical Magnetic Field at T=0 |
| $F_n$ | - Free Energy in Normal State |
| $F_s$ | - Free Energy in Normal State |
| $v_{so}$ | - Super Fluid Velocity |
| $\xi_o$ | - Size of Cooper Pair or Intrinsic Coherence Length |
| $\lambda$(T) | - Penetration Depth at any Temperature T |
| $\lambda$(0) | - Penetration Depth at T=0 |
| $H_0$ | - Ground State Hamiltonian |
| $H_i$ | - Hamiltonian for an i-th Interacting Cooper pair. |
| H | - Total Hamiltonian for *N* Interacting Cooper Pairs. |
| $b^\dagger$ | - Creation Operator for Cooper Pairs |
| $b$ | - Annihilation Operator for Cooper Pairs. |

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