DECLARATION

Declaration by candidate:

This thesis is my original work and has not been submitted for any academic award in any institution; and shall not be reproduced in part or full, or in any format without prior written permission from the author and/or University of Eldoret.

KIBOI DISMAS CHENGE Sign……………………. . Date…………………

SC/PGP/047/14

Declaration by supervisors:

This thesis has been submitted with our approval as university supervisors.

1. **PROFESSOR K.M.KHANNA** Sign…………… Date……………………

   DEPARTMENT OF PHYSICS,

2. **PROFESSOR J.K. TONUI** Sign…………… Date……………………

   DEPARTMENT OF PHYSICS,

DEDICATION

I am pleased to dedicate this MSc thesis to my dear wife Sarah Kuloba Buyube, my Parents Alice Chenge and Bramwel Chenge.

ABSTRACT

Superconductivity is an observable scientific fact exhibited by some materials at extremely low temperature approaching 0 K where their specific heat capacities (a thermodynamic bulk property) change as they transition to superconducting state from normal from normal. When the transition to the superconducting state is studied under a magnetic field, it is found that the specific heat difference or jump between the superconducting state (C_s) and the normal state (C_n) depends on the magnitude of the applied magnetic field. The specific heat jumps for conventional and unconventional superconductors occur at different applied magnetic fields in order to preserve the superconducting state of the material. The effects of the magnetic field on the value of specific heat jump for $LiTi_2O_4$ (usually refereed as LTO) were studied. This material is only one of its kinds in the midst of oxide superconductors in numerous features reminiscent of chemistry, crystal formation and superconducting properties. The consequence of applied magnetic field (H) on the specific heat jump and transition temperature of this material was established by deriving a correlation equation. The outcomes demonstrate that the existence of magnetic field enhances the superconducting state of the material since superconductivity in LTO is predominantly due to electron-electron interactions. The specific heat jump increases from the value 3.863745316mJmol^{-1} K^{-2} for H=2T to 55.09474118 mJmol^{-1} K^{-2} for H=32.8T. At $T = T_c$ the value of specific heat jump was calculated to be 38.3mJmol^{-1}K^{-2}, and the corresponding magnetic field, H was 22.369246T. This value falls within the range that has been reported by several researchers regarding LTO.

TABLE OF CONTENTS

Contents **Page**

DECLARATION ii
DEDICATION iii
ABSTRACT iv
TABLE OF CONTENTS v
LIST OF TABLES vii
LIST OF FIGURES viii
ABBREVIATIONS, ACRONYMS AND SYMBOLS ix
ACKNOWLEDGMENT xi
CHAPTER ONE 1
INTRODUCTION 1
1.1 Background of the study 1
1.2 Problem Statement 7
1.3 Objectives 7
1.3.1 General Objective 7
1.3.2 Specific Objectives 7
1.4 Justification of the study 8
CHAPTER TWO 9
LITERATURE REVIEW 9
2.1 Introduction 9
2.2 Theories for high temperature superconductivity 10
2.2.1 Bipolarons theory 11
2.2.2 Exciton theory 12
2.2.3 Spin bag theory 12
2.2.4 Friedel's theory 12
2.2.5 Resonating Valence Bond state theory 13
2.2.6 Plasmon Mechanism Theory 14
2.3 Properties of HTSC 14
2.4 Meissner effect 14
2.4.1 Exclusion of the flux 15
2.5 Room temperature superconductivity 17
CHAPTER THREE 25
THEORETICAL DERIVATIONS 25
3.1 Introduction 25
3.2 Theoretical derivations 25
Equations (3.40) and (3.41) will be used to calculate the specific heat jump at
in terms of the applied magnetic field H. 33
CHAPTER FOUR 34
RESULTS AND DISCUSSION 34

4.1 Introduction 34
4.2 The Value of specific heat jump
for LTO in the presence of magnetic field. 34
4.3 The magnitude of the transitional magnetic field for LTO. 36
CHAPTER FIVE 39
CONCLUSION AND RECOMMENDATION 39
5.1 Conclusion 39
5.2 Recommendation 40
REFERENCES 41
APPENDICES 47
Table Appendix 1: Values of specific heats in the normal 47
and superconducting states for the temperature range 1-20K 47
obtained from equations (3.29) and (3.33) 47

Table Appendix 2: Numerical data of magnetic field, 49
H and specific heat jump, obtained from equations 49
(3.40) and (3.41) 49

LIST OF TABLES

Table **Page**

Table Appendix 1 Values of specific heats in the normal and superconducting states for the temperature range 1-20K...49

Table Appendix 2 Numerical data of magnetic field, H and specific heat jump,......51

LIST OF FIGURES

Figure **Page**

Figure 2.1 Illustration of Meissner effect 17

Figure 2.2 Illustration of type I superconductors 19

Figure 2.3 Illustration of type II superconductors……..21

Figure 4.1 Specific heat capacity versus temperature...37

Figure 4.2 Specific heat jump versus applied magnetic field..............................39

ABBREVIATIONS, ACRONYMS AND SYMBOLS

$ARPES$	Angle-resolved photoemission spectra
BCS	Bardeen Cooper Schrieffer (Theory)
C_v	Specific heat at constant volume
C_s	Specific heat in superconducting state
C_n	Specific heat in normal state
dos	Density of states
G_s	Gibb's free density at superconducting state
G_n	Gibb's free density at normal state
G_{NS}	Gibb's free energy per unit volume
H	Magnetic field
H_c	Critical magnetic field
$H_c(T)$	Critical magnetic field at T at which the superconducting state disappears
HTSC	High temperature superconductors
LTSC	Low temperature superconductors
LTO	Lithium Titanium Oxide
MRI	Magnetic Resonance Imaging
M	Magnetic intensity
MR	Magnetoresistance
p	Pressure

RVB	Resonating valence bond (Theory)
SQUIDs	Superconducting Quantum Interference Devices
S_s	Entropy per unit volume in superconducting state
S_n	Entropy per unit volume in normal sate
T_c	Critical transition temperature
T_f	Fermi temperature
T	Temperature
u	Internal energy
u_m	Magnetic energy
vHs	Van Hove Singularities
v	Volume per mole
x	Magnetic susceptibility
γ	Specific heat coefficient
λ	Penetration depth
ΔC	Specific heat jump

ACKNOWLEDGMENT

I thank the Almighty God for having given me sound mind and good health during the entire period of my Msc. work.

The Univerty of Eldoret gave me an opportunity to build up my career. I thank its management and staff for the profound programs that make systems run. Allowing me use the available resources in the University to carry out my Msc. Work was tremendously remarkable.

My supervisors Professors JK Tonui and KM Khanna played an outstanding role in inculcating in me the best scientific knowledge in my entire Msc Work. I am highly indebted to them for their availability and sacrifice to attend to my thesis work unconditionally.

I say kudos to My Classmates Mr. S. Chemogos and Mrs. R. Julia who were very supportive in boosting my morale to go on with my work. Their presence and encouragement stirred up my passion to bring the thesis work to completion. Their keenness and interest to point out mistakes in my work whenever they read kept me on toes.

I hold my parents Mrs. A. Chepsagit and Mr. B. Chenge together with my siblings led by Mr. M. Mono so dear. Their moral support was remarkable. They were always consistent in cheering me up to present commendable work.