# Contents

Publication List ................................. i

Acknowledgments ................................ ii

Abstract ......................................... iii

1 Introduction ...................................... 1
   1.1 Ferromagnetic Kondo Lattice Model .............. 1
   1.2 Geometrical Frustration ......................... 2
   1.3 Spin Scalar Chirality and Unconventional Anomalous Hall Effect .... 3
   1.4 Purpose of This Thesis .......................... 5
   1.5 Organization of this thesis ..................... 6

2 Model and Method ............................... 7
   2.1 Model Hamiltonian ............................. 7
   2.2 Variational Calculation of Ground-State Energy .......... 8
   2.3 Perturbation theory in $J_H/t$ .......................... 13

3 Results and Discussions ....................... 17
   3.1 Triangular Lattice ............................ 17
       3.1.1 Numerical comparison of grand-canonical potential .... 17
       3.1.2 Perturbation calculation of grand-canonical potential .... 19
       3.1.3 Ground state phase diagram: noncoplanar four-sublattice order at 1/4 filling 21
       3.1.4 Hall Conductivity .......................... 24
       3.1.5 Lightly-doped region: noncoplanar three-sublattice order .... 26
   3.2 Stability of noncoplanar order at 1/4 and 3/4 filling: Triangular-Kagome Lattice ......................... 31
   3.3 Stabilization mechanism of scalar chiral order ............ 32
       3.3.1 Effective spin Hamiltonian in the fourth-order perturbation in $J_H/t$ 32
       3.3.2 Origin of positive biquadratic interaction ......... 35
       3.3.3 Non-perturbative effect with level repulsion ......... 36
   3.4 Other frustrated lattices ...................... 41
       3.4.1 Face-centered-cubic lattice ............... 41
       3.4.2 Checkerboard lattice .......................... 45
### Contents

3.4.3 Pyrochlore lattice .................................................. 47  
3.5 Relation to Other Theoretical Studies .......................... 49

4 Summary ........................................................................ 50  

A Formulation of Hall Conductivity ................................ 52  
B Ground-state phase diagram for a triangular-kagome lattice model ............................................. 54  
C Perturbation Calculation ................................................. 57