KTH Engineering Sciences

Introduction to Spintronics

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Preface

Spintronics is a field of Physics that has been experiencing an explosive growth in the last decade. This is due to a range of new spin-dependent transport phenomena discovered recently as well as their potential for large scale applications. The new physics as well as the growing interest from the industrial research and development provides motivation for many students to get familiar with the subject. The present text accompanies a yearly course for diploma and graduate students on Spintronics, given at the Department of Physics of the Royal Institute of Technology in Stockholm. A number of books on the subject have been published recently, typically containing collections of reviews by the experts in the respective fields. These books, being an excellent reference material for in-depth studies or research, often contain contributions of weakly coherent content and style, requiring from the student varying levels of training in physics and mathematics. Some of them are merely a collection of references to the original literature. The present compendium is an attempt to provide a self-contain reference text on Spintronics. It is essential to have knowledge of the basics of magnetism and condensed matter physics for understanding the spin-dependent transport phenomena. These two disciplines, however, are elective for students at most universities. We, therefore, dedicate the opening chapters to discussing the necessary concepts of magnetism and condensed matter physics, before treating the more specialized topics of spin-dependent transport.

Introduction

The subject of Spintronics is broad and benefits from several fields of science, such as Physics, Materials Science, Engineering. We will not in this course attempt to cover all of the topics, and will focus on presenting as clearly and concisely as possible only the physical principles of the spin-dependent transport phenomena. The course is concluded with a discussion of how these phenomena are or can be used in technology. The first chapter discusses the origins of atomic magnetism, which is the foundation for all magnetic effects discussed later on in the course. It is our experience that many physics and engineering physics students graduate without attending a specialized course on Magnetism. We, therefore, dedicate three lectures to reviewing the magnetism concepts used later in the course. Chapter 5 discusses the basics of charge transport in metals and semiconductors. Spin polarization of electron distributions in magnetic materials and how it leads to new magneto-transport effects are discussed in Chapter 6. Chapters 7 through 11 is the core of the course, where the effects of Giant Magnetoresistance, Tunnelling Magnetoresistance, Spin Transfer Torques, and the Spin Transistor are analyzed. The course concludes with a review of the recent and potential applications of the spintronic effects. Even though there is some consensus on what is of high importance in todays spintronics, a topical selection like this one is subjective. A discovery of an efficient semiconductor based spin transistor or a useful spin based quantum computer may change the field dramatically. At this time, however, we felt that the students will best be served by studying the material presented herein.

Contents