ABSTRACT IN ENGLISH

Non relativistic spin splitting is typically a characteristic phenomenon observed in systems with broken time-reversal symmetry. It is primarily influenced by the effect of magnetic exchange interaction J_{ex} between the spins causing an energy shift between spin-up and spin-down electrons. The occurrence of spin splitting cannot be observed in a system where the time-reversal symmetry (TRS) is preserved, as this symmetry leads to the Kramer's degeneracy. The spin-splitting occurs independently of spin-orbit coupling (SOC) effects though its presence can produce interesting effects through its interplay with the spin-splitting, such effects will be the main topic of this thesis. The property of non-relativistic spin-splitting has proved its importance in spintronics and has several effects on the materials' properties. For example, it can lead to the formation of spin-polarized currents and with SOC can lead to spin Hall (SHE) and anomalous Hall effects (AHE).

The presence or absence of symmetries has become one of the most important aspects in condensed matter physics as it leads to the description of robust phenomena, especially in magnetic and topological systems. The effect of broken space-inversion symmetry in large SOC systems, for instance, is necessary for the presence of the Dzyaloshinskii-Moriya interaction (DMI) which leads to the creation of chiral magnetic structures arising from spin dynamics. In addition, breaking time-reversal symmetry is essential for the emergence of transport responses, such as the AHE, which not only depends on SOC but can also be controlled by its effects. In the presence of spin-orbit coupling in systems with broken inversion symmetry, other significant effects such as the Rashba spin-orbit and the Dresselhaus effect can arise. Furthermore, in topological materials, the breaking of the time-reversal symmetry can give rise to topological Weyl semi-metals.

This thesis includes studies of a few systems characterized by the property of broken time-reversal symmetry exhibiting non-relativistic spin-splitting of energy bands visible in the band structure where its interplay with spin-orbit coupling can generate DMI and/or AHE. These systems with broken time-reversal symmetry can be classified into two categories:

1. **Ferromagnetic systems**: Magnetic thin films of Re/Co/Pt were studied in the first two papers; this system produces very high DMI values due to the availability of the vital conditions. Space-Inversion symmetry is broken due to the presence of interfaces, and the effect of SOC is relatively too strong stemming mainly from platinum. This work presented in Chapter 3, is purely theoretical, based on density functional theory calculations (DFT) in which we examine the effect of tuning the thickness of Co thin films and the effect of interface intermixing on the overall dynamics of the studied system. Chapter 4, is a collective experimental and theoretical study of the same system, it focuses mainly on the importance of interface type and quality on the DMI contribution. Chapter 5, the anomalous Hall effect in the Weyl semi-metal CeAlSi, specifically in its ferromagnetic phase in our DFT calculations, was studied using the Wannierization method. The Weyl points present

in this system originate from the breaking of the inversion symmetry as well as from the lack of TRS. In the presence of SOC, the positions of these Weyl points were monitored and associated with a sign change in the AHE results.

2. **Altermagnetic systems:** Recently, research was ignited with the concept of a new type of magnetism dubbed "altermagnetism" characterized by spin-splitting in the band structure regardless of its compensated magnetization constrained by symmetry. Breaking the time-reversal symmetry in altermagnetism has been an important feature in exploring macroscopic responses that were already seen in ferromagnets. In Chapter 6, CrAs, an altermagnetic candidate, is examined. The effect of SOC acts selectively on the band crossings/anticrossings producing an anomalous Hall effect.

Chapter 1 is an introduction to magnetism, spin-orbit coupling, and symmetries in condensed matter physics. Chapter 2 is devoted to the computational framework. Chapters 3 to 6 include the publications discussed, while Chapter 7 is dedicated to future outlooks and discussions.