1 Topological materials

In this chapter, we consider various concepts from physics that are relevant in the context of topological materials. Firstly, the symmetry related concepts of parity, time reversal, Kramer's degeneracy, and accidental degeneracy are explained. Then, the concept of linear dispersion in Weyl and Dirac cones is discussed, along with some useful results. Lastly follows a quick summary of spin-orbit interactions. The chapter is intended as a quick introduction to the vast field of topological materials for someone who are not familiar with these concepts.

Some topics discussed are directly applicable to the thesis, while others are included both in order to put the concepts of the thesis in a greater context, and also with regards to further continuation of this work.

1.1. Parity

We consider now the discrete transformation of space inversion, or *parity*. Firstly, basic properties of the transformation will be presented and discussed. Its effect on the position, momentum, and angular momentum operators will be discussed, before a more general discussion on how it transforms proper- and pseudo-tensors. This will be applied to see how the parity transformation affects electric and magnetic fields.

Let the parity operator P be a unitary operator

$$P: \quad |a\rangle \to P|a\rangle . \tag{1.1}$$

By definition, we require

$$P^\dagger x P = -x, \tag{1.2}$$

$$P^\dagger p P = -p, \tag{1.3}$$

where x, p are the position and momentum operators. By the unitarity of P, which means that $P^\dagger P = I$,

$$xP = -Px.$$

We now use this anticommutation to find an explicit form of the transformation in the position representation. By noting that, given the position eigenstate $|x_1\rangle$,

$$xP|x_1\rangle = -Px_1|x_1\rangle = -x_1 P|x_1\rangle , \tag{1.4}$$

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