Foreword

It is almost 200 years, since Georg Ohm published his research on the galvanic response of a metal to an applied voltage, amid a storm of controversy. He gave us, one of the handfuls of physics equations that everybody learns, $V = IR$. Now, we prefer to relate the linear galvanic response to the electric stimulus, via the intrinsic electrical conductivity, σ, of the metal, $\boldsymbol{j} = \sigma \boldsymbol{E}$. Some 20 years later, William Thomson discovered both the quadratic decrease of conductivity of a normal metal in a magnetic field – the normal magnetoresistance – and its variation with the angle between the electric current and the magnetization $\boldsymbol{M}$, in a ferromagnetic metal. Near the end of the 19th century, Edmund Hall found that in a perpendicular magnetic field, a current excites a transverse voltage proportional to the current in a normal metal, and proportional to magnetization in a ferromagnet – the normal and anomalous Hall effects.

Shortly afterwards, the electron with its tiny mass and unchanging quantum of negative charge $-e$ was identified as the mobile carrier of electric current, but its ability to transport the angular momentum associated with its intrinsic spin of $\hbar/2$ discovered in the 1920s, attracted little attention. This was because, unlike the charge, the angular momentum of the electron could be flipped in a collision with another electron. Spin diffusion lengths, measured in nanometres, are a small multiple of the electrons' mean free path. Anisotropic magnetoresistance and anomalous Hall effect became familiar effects but remained unexplained for much of the 20th century. Only when it became possible, in the 1970s to prepare high-quality magnetic thin films and heterostructures, thinner than the spin diffusion length, did 'spin electronics' become a practical possibility.

Since then, there has been an avalanche of discovery of new magneto-electric phenomena, and spintronics has found important applications in contactless sensing, scalable non-volatile memory, and fast electronic switching. A bewildering array of new ideas and phenomena has emerged, many associated with spin-orbit interaction. Topology in direct and reciprocal space is an important consideration.

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A page is needed to list the acronyms, let alone explain the physical effects. There is much for a newcomer to the field to master, both conceptually and practically. Vincent Baltz's new book is a welcome guide to the first aspect, for both newcomers and practitioners of the art of spin-dependent electron transport.

Here is a concise, meticulously-illustrated account of the subject with necessary, but not excessive mathematical detail, which will allow the reader to grasp the basic concepts and learn how to use them in the ten extended exercises, that form an integral part of the text. A common notation and a single system of practical SI units is adopted throughout, which helps to reduce the confusion of conventions and units, found in the literature. Familiarity with the numerical values of the quantities involved will allow the reader to develop a critical, physical feel for the subject. Baltz's book is based on a series of lectures, given to students in Grenoble, in recent years. It will serve as a Baedeker for travellers in the rugged and testing terrain of contemporary spintronics.

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