# Skyrmions, Non-commutative Geometry and Hall Effect

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Magnetic skyrmions are fascinating particle-like objects, whose key properties are governed by their non-trivial real-space topology. Microscopically, this topology manifests in the presence of the so-called emergent gauge field, which directly couples to electronic degrees of freedom thus giving rise to such fundamental effects as for example the topological Hall effect. In strongly spin-orbit coupled systems our perception of skyrmions as gauge-field generating particles has to be conceptually altered, however, and we show that this can be naturally done by referring to the paradigm of non-commutative geometry [1]. We show that in terms of this powerful language, also utilized in the realm of quantum Hall effect, nuclear physics and string theory, skyrmions re-emerge as entangled objects living in a complex non-commutative phase space. Inspired by our previous work [2], we will demonstrate the emergence of a Hall effect in chiral magnetic textures which is neither proportional to the net magnetization nor to the topological emergent magnetic field. We show that this "chiral" Hall effect receives a natural interpretation in the language of non-commutative geometry, thus conceptually relating magnetic skyrmions to quantum Hall systems [3]. Moreover, we argue that the chiral Hall effect could provide a distinct magneto-transport signature of non-commutative geometry of complex spin textures which is distinctly different from that driven by the topological Hall effect [4].

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