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Spin-orbit torques and charge pumping in crystalline magnets

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In magnetic crystals with an inversion asymmetric unit cell a non-zero global spin-polarization is generated by an electrical current, which acts with a torque on the magnetisation exciting magnetic dynamics [1]. This relativistic non-equilibrium spin phenomenon also has a reciprocal effect in which the excitation of magnons results in the pumping of a charge current [2]. The possibility to manipulate/read magnetism with electrical currents is highly relevant for magnetic memories and other spintronic devices. I will start by reviewing our recent research on spin-orbit torques (SOTs) in crystalline magnets, in particular our very recent measurements of the crystalline SOT at room temperature in half-Heusler NiMnSb thin films. With this experiment we are able to fully characterise magnitude and symmetry of the SOTs [3, 4]. I will then talk about the first demonstration of magnonic charge pumping in crystal magnet GaMnAs [2]. In this effect, which is the reciprocal effect of SOTs, the precessing ferromagnet pumps a charge current. Differently from spin pumping, which is commonly used to electrically detect magnetization dynamics, in charge pumping magnons are converted within the ferromagnet into high-frequency currents via the relativistic spin-orbit interaction, without the need of a secondary spin-charge conversion element, such as heavy metals with large spin Hall angle. References 1. Chernyshov et al., Nature Physics 5, 656 (2009). 2. Ciccarelli et al., Nature nanotechnology 10, 50 (2014). 3. Fang et al., Nature Nanotechnology 6, 413 (2011). 4. Kurebayashi et al., Nature Nanotechnology 9, 211 (2014).