Microscopic theory of ultrafast optical skyrmion excitation in magnetic thin films

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Magnetic skyrmions can be excited by irradiating atomically thin magnetic films with femtosecond laser pulses. We here propose a microscopic theory of electronically driven optical skyrmion excitation based on a two-band electronic model coupled to an external electromagnetic field. This allows to couple the electric field of the laser directly to the charge of the electrons thus enhancing the light-matter coupling. In the strong correlation limit we describe the localized magnetic moments of the d-band in terms of an effective spin model, with a local exchange coupling to the itinerant s-band electrons. For strong $s-d$ coupling we find that irradiation by femtosecond laser pulses leads to skyrmion excitation on a 100 fs timescale. Numerical results combined with an analytical treatment of the strong $s-d$ coupling limit identify the coupling between the electronic current and the localized magnetic moments, mediated via the interfacial Rashba spin-orbit interaction, as the mechanism driving ultrafast optical skyrmion excitation.