From the discovery to the control of THz spin currents: towards ultrafast spintronics

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The debate over the origin of the ultrafast demagnetization[1] has been intensively active for the past 16 years. Several microscopic mechanisms have been proposed but none has managed so far to provide direct and incontrovertible evidences of their validity. In this context we have proposed an approach based on spin dependent electron diffusion as the driver of the ultrafast demagnetization.[2]

Recent experimental findings have revolutionized the field by confirming the existence of spin superdiffusion. We have shown that 1) spin diffusing away from a layer undergoing ultrafast demagnetization can be used to create an ultrafast increase of magnetization[3] in a neighboring magnetic layer, 2) optical excitation is not a prerequisite for the ultrafast demagnetization[4] and that spin unpolarised electrons superdiffusing into a ferromagnetic layer can trigger ultrafast demagnetisation, and 3) superdiffusive spin currents can be tailored by appropriate choice of materials and used to produce broadband THz emission via the inverse spin Hall effect.[5]

The impact of these new discoveries goes beyond the solution of the mystery of ultrafast demagnetization. It shows how spin information can be, not only manipulated, as shown 16 years ago, but most importantly transported at unprecedented speeds. This new discovery lays the basis for femtosecond spintronics.

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