Thermal Torques

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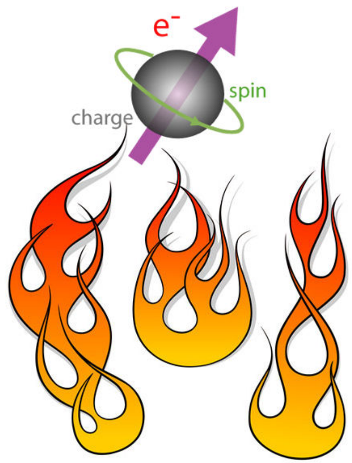
- Introduction
- M. Kläui: ***Thermal Torques and SSE***
- M. Costache: ***Magnon Transport in Metallic Nanostructures*** (magnon drag in NiFe structures)



PRL **99,** 066603 (2007) PHYSICAL REVIEW LETTERS week ending 10 AUGUST 2007

Thermal Spin-Transfer Torque in Magnetoelectronic Devices

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We predict that the magnetization direction of a ferromagnet can be reversed by the spin-transfer torque accompanying spin-polarized thermoelectric heat currents. We illustrate the concept by applying a finite-element theory of thermoelectric transport in disordered magnetoelectronic circuits and devices to metallic spin valves. When thermalization is not complete, a spin heat accumulation vector is found in the normal-metal spacer, i.e., a directional imbalance in the temperature of majority and minority spins.

DOI: 10.1103/PhysRevLett.99.066603 PACS numbers: 72.15.Jf, 75.30.Sg, 75.60.Jk, 85.75.−d

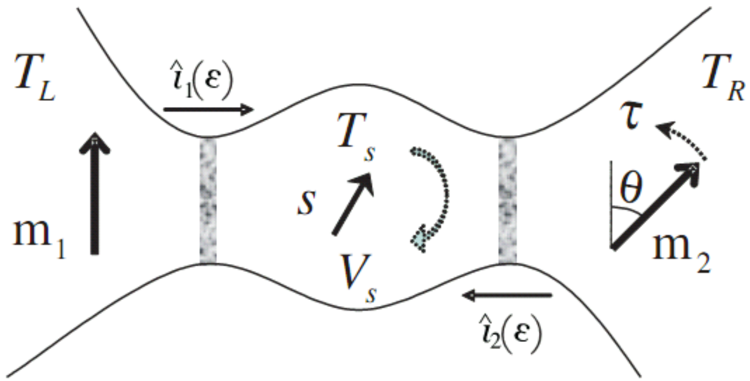
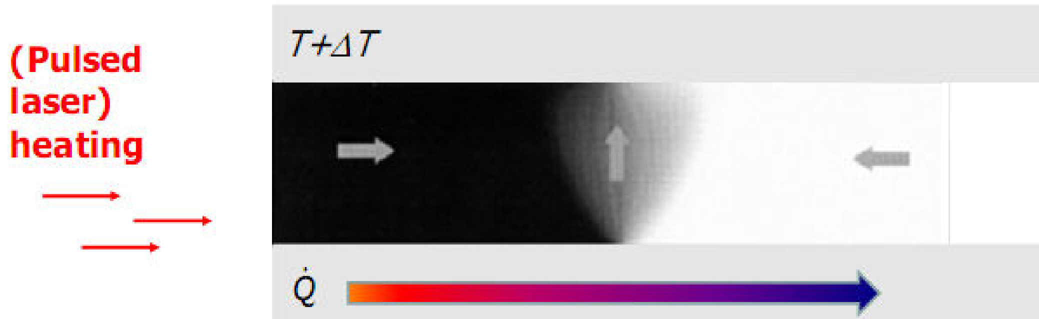


FIG. 1 (color online). Schematic of a noncollinear $F(\mathbf{m}_1)|N|F(\mathbf{m}_2)$ spin valve. Spin-dependent resistive elements separate the ferromagnetic reservoirs and the normal-metal node. A temperature bias induces a spin accumulation in the form of heat and angular momentum imbalance, the interplay of which is governed by inelastic scattering.



PHYSICAL REVIEW B **82**, 054403 (2010)

Initiation of spin-transfer torque by thermal transport from magnons

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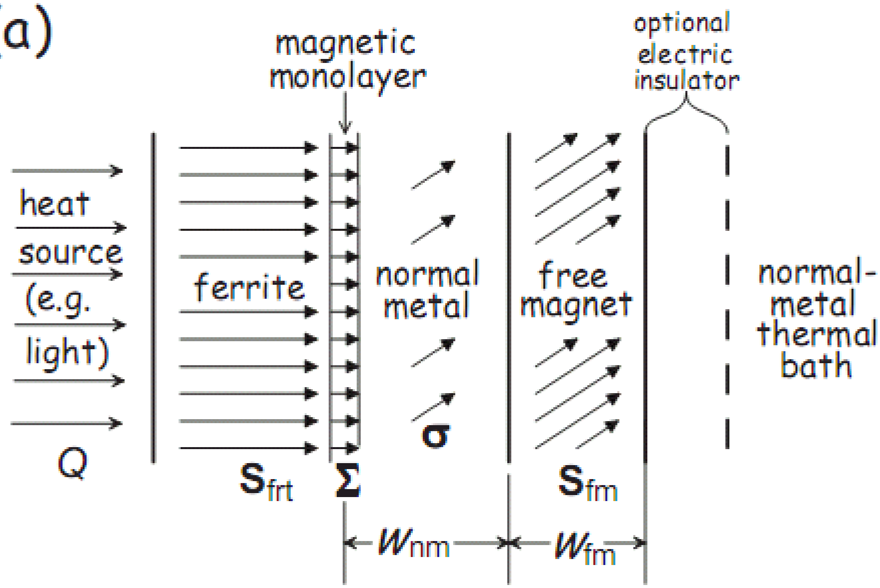
(a)



- Experimental evidence is scarce !

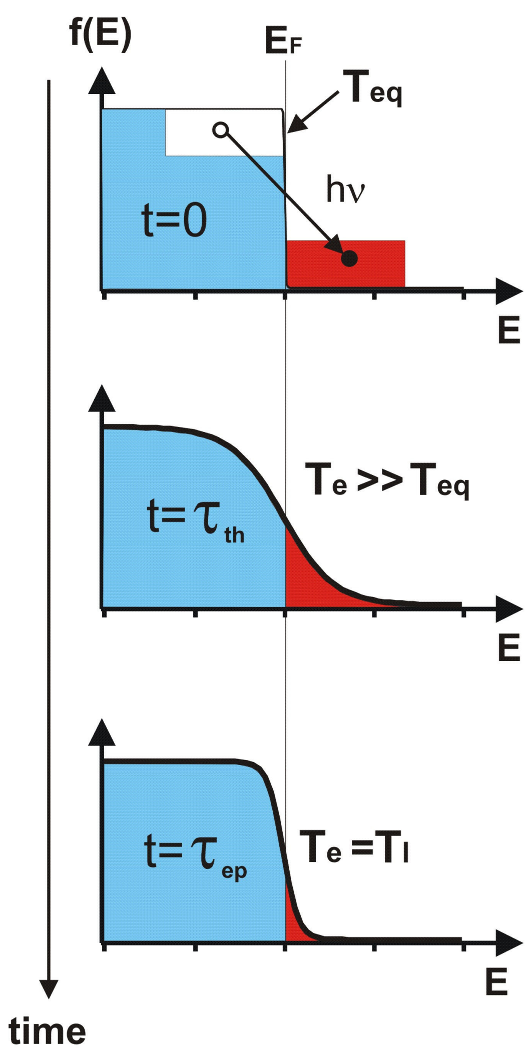
- J.-P. Ansermet (Monday, „Interfaces“)
- B. Hillebrands (Tuesday, „Magnons“)
- S.M. Rezende (Tuesday, „Spin Seebeck Effect“)
- M. Kläui (this session)

Experimental problems:

- How to create large temperature gradients (in planar structures)?

- If using pulsed laser heating how to separate spurious effects?
- If using electrical detection, how to separate spurious efects?
- If observing domain wall motion induced by thermally induced transfer torque, how to separate spurious effects?

Pulsed laser heating
temperature gradients of 0.1 K/nm are easily achieved, in particular in layer stacks



Electron dynamics upon fs-laser excitation

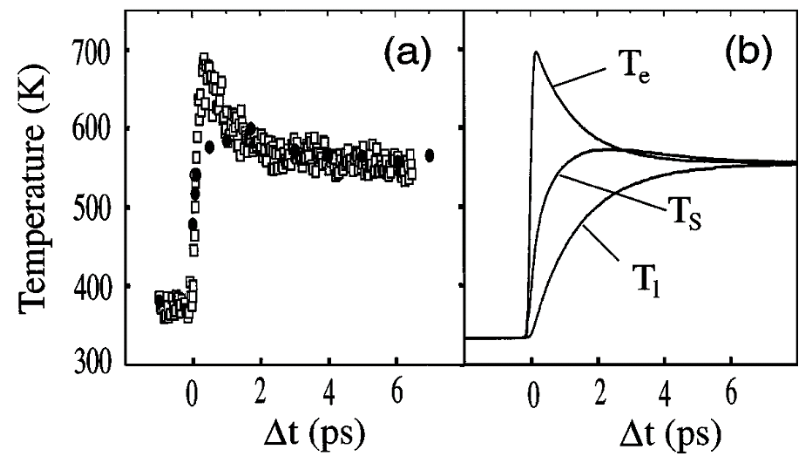


FIG. 3. (a) Experimental spin (T_s) and electron (T_e) temperatures estimated as explained in the text. The experimental conditions are those of Fig. 2. (b) Calculated spin (T_s), electron (T_e), and lattice (T_l) temperatures from Eqs. (1). The relevant parameters are given in the text.

Beaurepaire et al., Phys Rev. Lett. **76**, 4250 (1996)

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Superdiffusive Spin Transport as a Mechanism of Ultrafast Demagnetization

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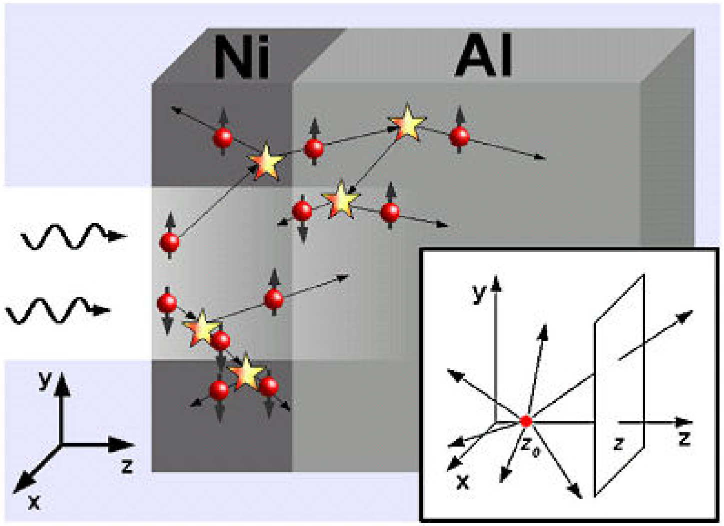
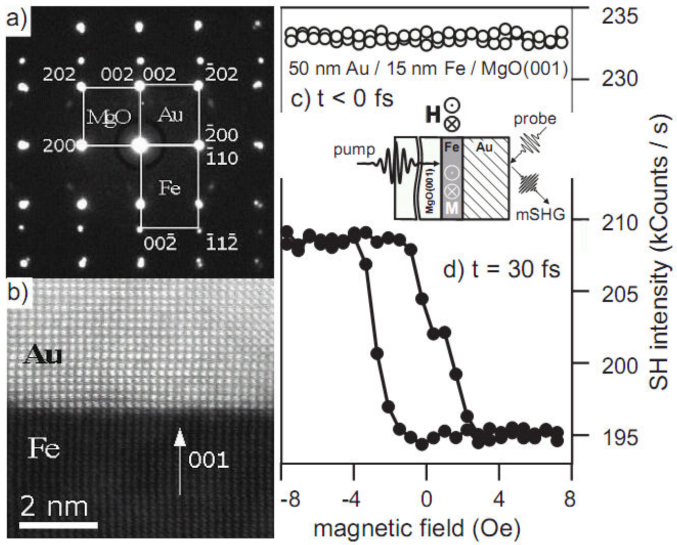
(Received 31 March 2010; published 9 July 2010)

We propose a semiclassical model for femtosecond laser-induced demagnetization due to spin-polarized excited electron diffusion in the superdiffusive regime. Our approach treats the finite elapsed time and transport in space between multiple electronic collisions exactly, as well as the presence of several metal films in the sample. Solving the derived transport equation numerically we show that this mechanism accounts for the experimentally observed demagnetization within 200 fs in Ni, without the need to invoke any angular momentum dissipation channel.

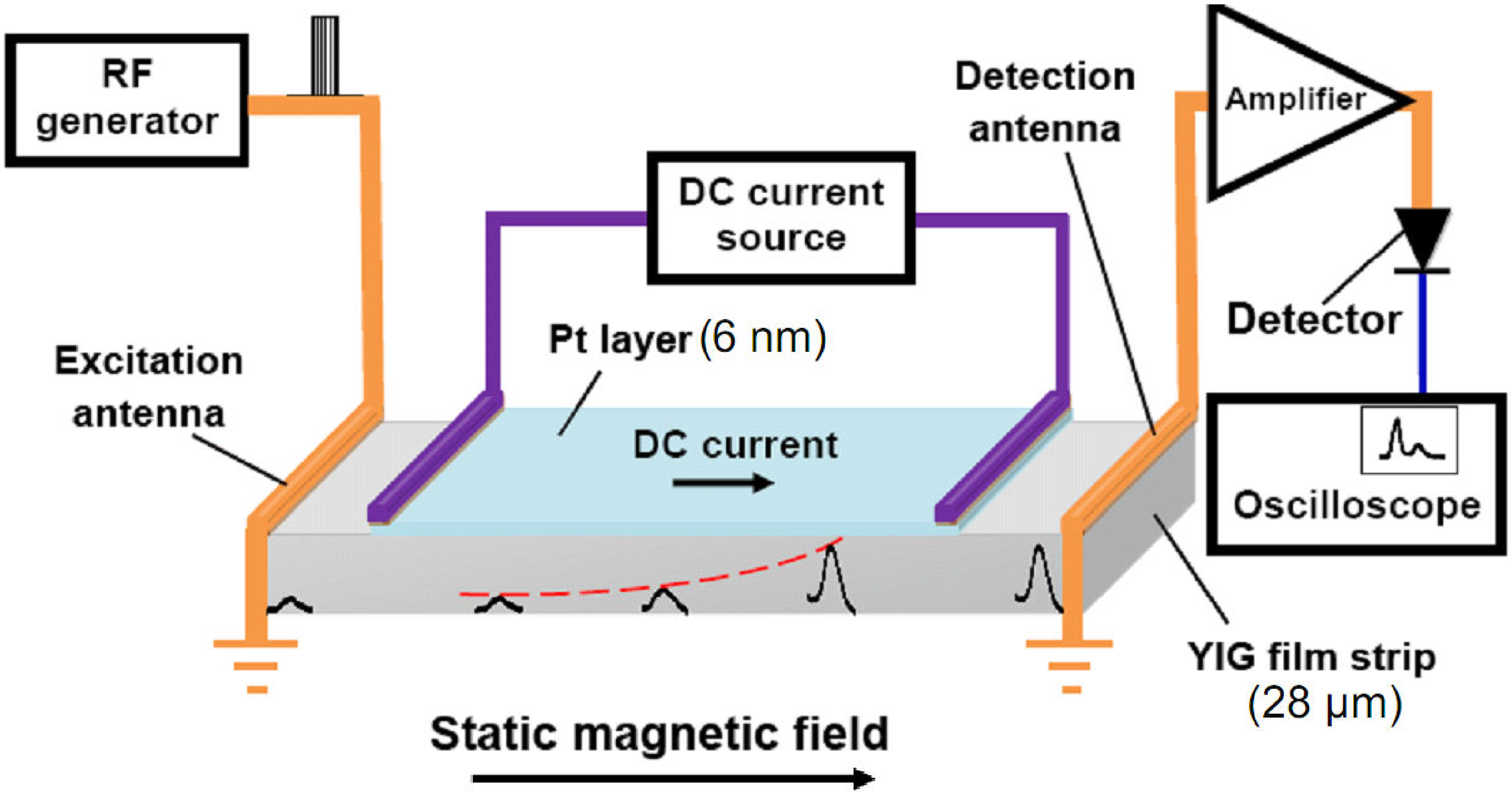
DOI: 10.1103/PhysRevLett.105.027203 PACS numbers: 75.78.Jp, 72.25.−b, 75.76.+j, 78.47.J−



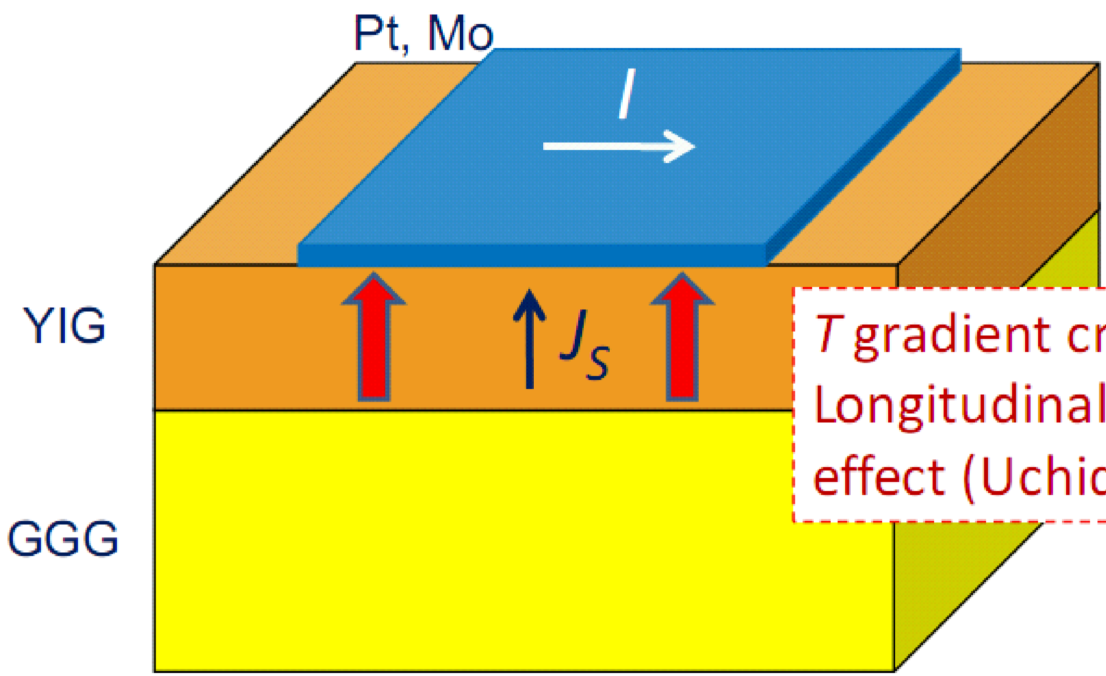


Melnikov et al., arXiv:1103.5310v1

More experimental evidence ?



Spin Seebeck effect? Spin-wave model



T gradient creates J_s
Longitudinal spin Seebeck effect (Uchida et al 2010)

$$J_S = \beta \nabla T$$

$\beta \propto S_s$ (spin Seebeck coefficient)

$$\vec{\tau} = -J_S \; \vec{S} \times (\vec{\sigma} \times \vec{S})$$

Spin torque due to spin current J_S created by the SSE

Hatami, Zhang, Bauer, Kelly, PRL 2007
Slonczewski, PRB 2010