Probing Ultrafast Optical Demagnetization with an HHG Source

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ALLS Advanced Laser Light Source

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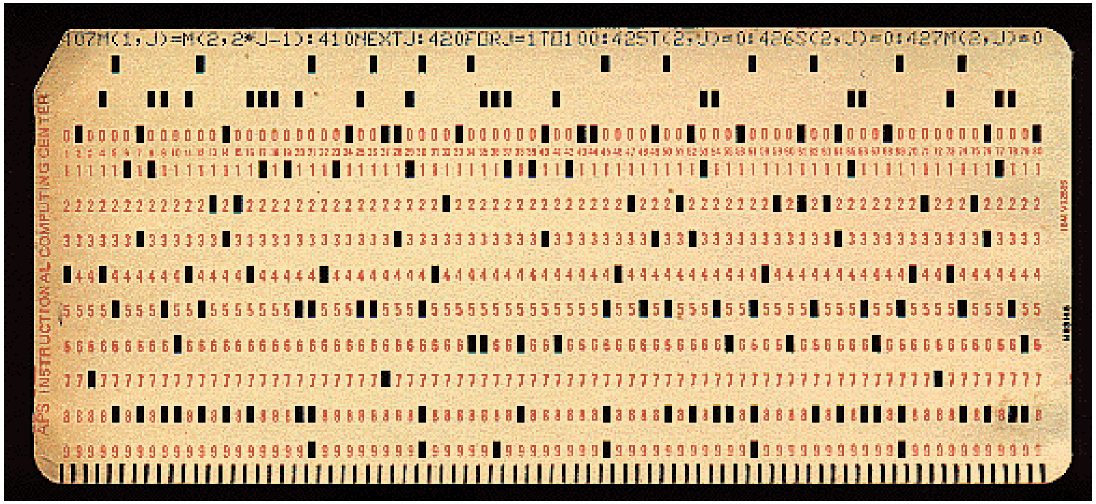
Studying Ultrafast Optical Demagnetization

Motivation



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Ultrafast Optical Demagnetization

Discovery

Article by *Beaurepaire et al.* in Physical Review Letters, 1996.

VOLUME 76, NUMBER 22 PHYSICAL REVIEW LETTERS 27 MAY 1996

Ultrafast Spin Dynamics in Ferromagnetic Nickel

E. Beaurepaire, J.-C. Merle, A. Daunois, and J.-Y. Bigot

Institut de Physique et Chimie des Matériaux de Strasbourg, Unité Mixte 380046 CNRS-ULP-EHICS, 23, rue du Loess, 67037 Strasbourg Cedex, France

(Received 17 October 1995)

The relaxation processes of electrons and spins systems following the absorption of femtosecond optical pulses in ferromagnetic nickel have been studied using optical and magneto-optical pump-probe techniques. The magnetization of the film drops rapidly during the first picosecond, but different electron and spin dynamics are observed for delays in the range 0–5 ps. The experimental results are adequately described by a model including three interacting reservoirs (electron, spin, and lattice). [S0031-9007(96)00167-6]

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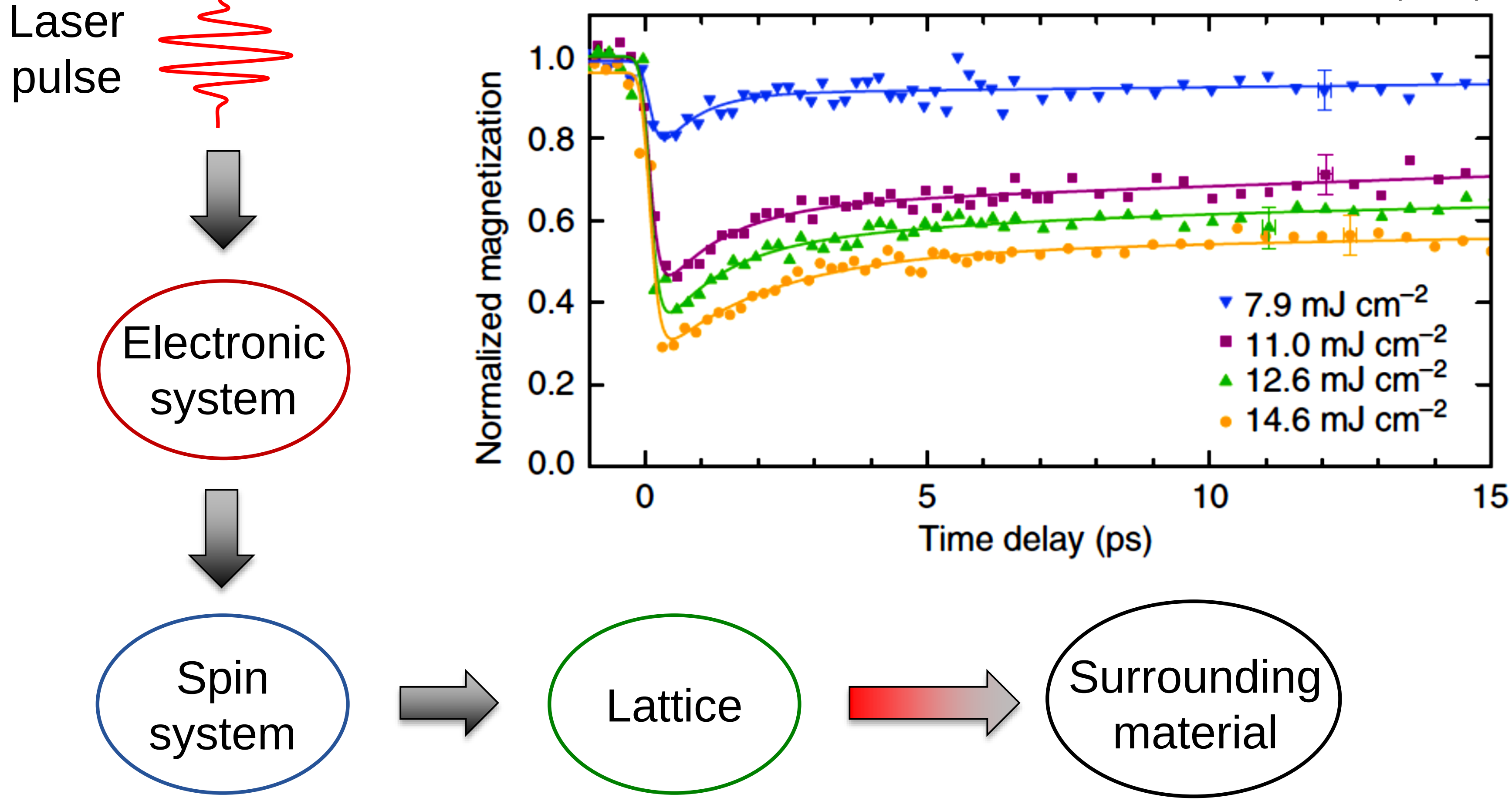
Ultrafast Optical Demagnetization

Three temperature model

Pfau, B *et al.* Nat. Commun. **3** (2012).



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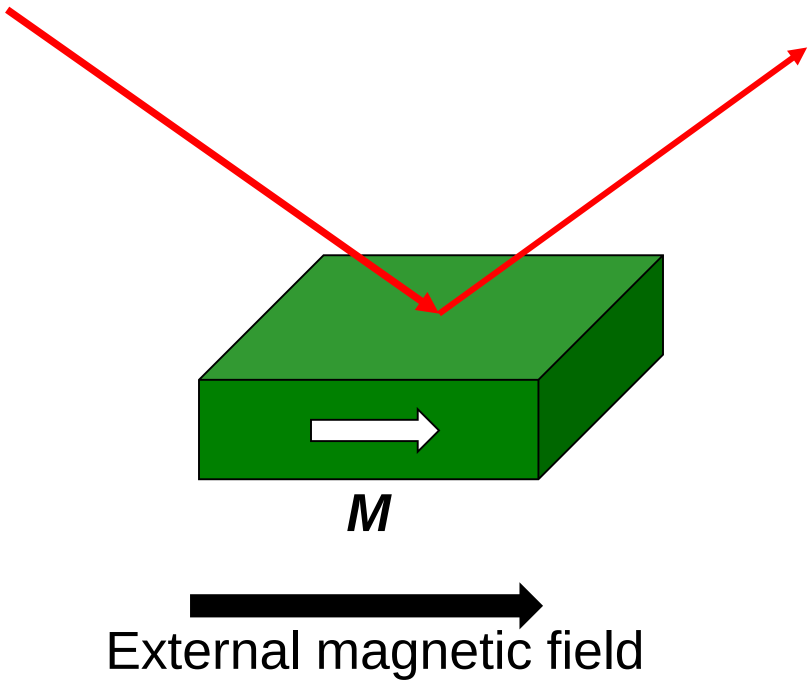
Magnetization Amplitude Probing Technique

MOKE (Magneto-Optic Kerr Effect)

- Technique used by *Beaurepaire et al.*
- Reflectivity measurement
- Near infrared pump and probe



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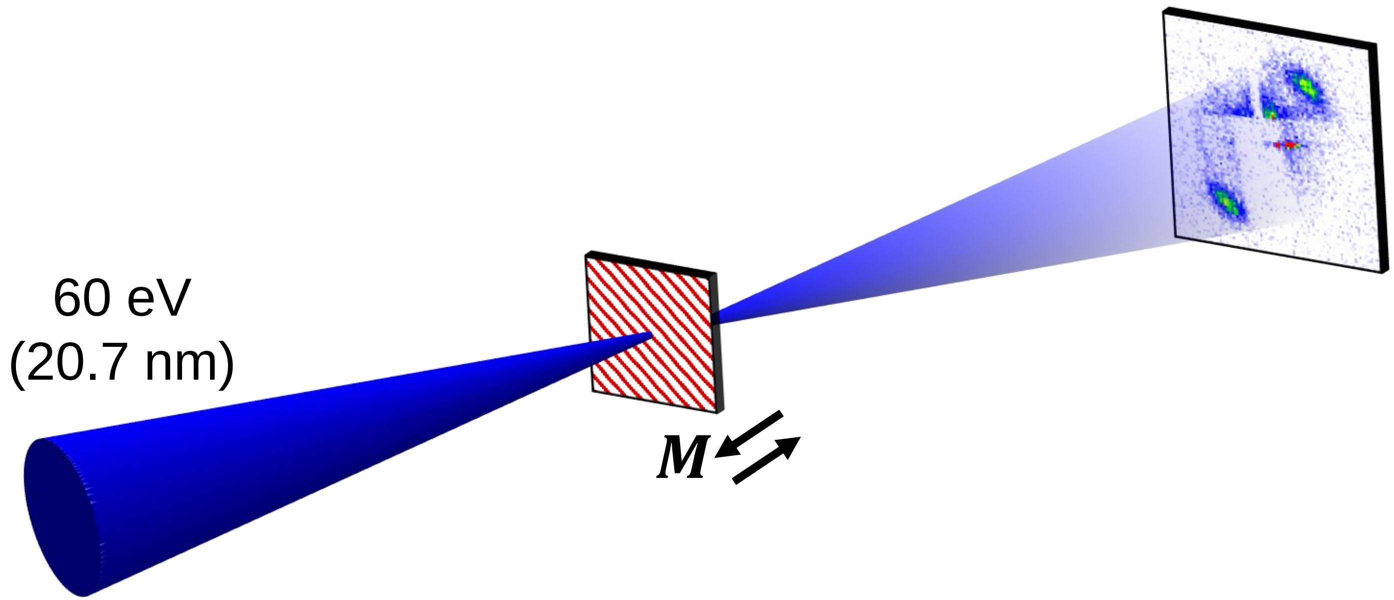
Magnetization Amplitude Probing Technique

RXMS (Resonant X-ray Magnetic Scattering)



$$f^n = (e_s^* \cdot e_i) f_c^n + i(\boldsymbol{e}_s^* \times \boldsymbol{e}_i) \cdot \boldsymbol{M}^n f_{m1}^n + (e_s^* \cdot M^n)(e_i \cdot M^n) f_{m2}^n$$

$$I \propto T\boldsymbol{M}^2$$

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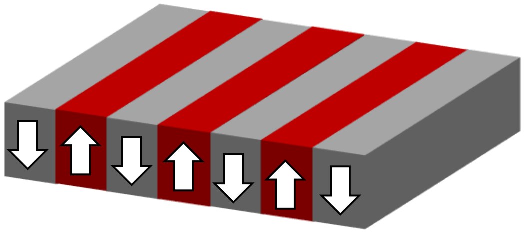
Magnetization Amplitude Probing Technique

RXMS (Resonant X-ray Magnetic Scattering)

- XUV probe – spatial resolution
- No need for an external magnetic field
- Holds information on the magnetic structure of the sample

- Low efficiency (10^{-6})
- Requires a specific magnetic structure
- Magnetization must be out-of-plane



How to produce short XUV pulses?

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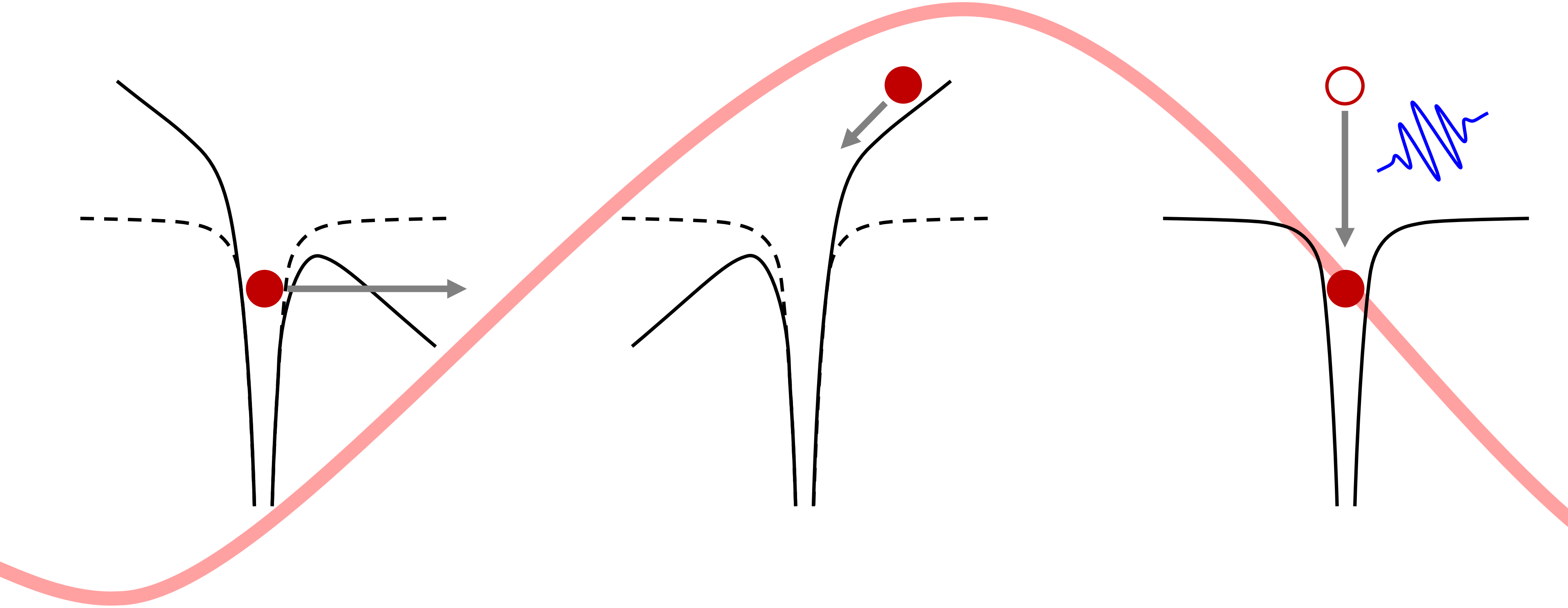
Experimental Details

High Harmonics Generation

Three-step model, P. B. Corkum, Phys. Rev. Lett. 71, 1994 (1993)



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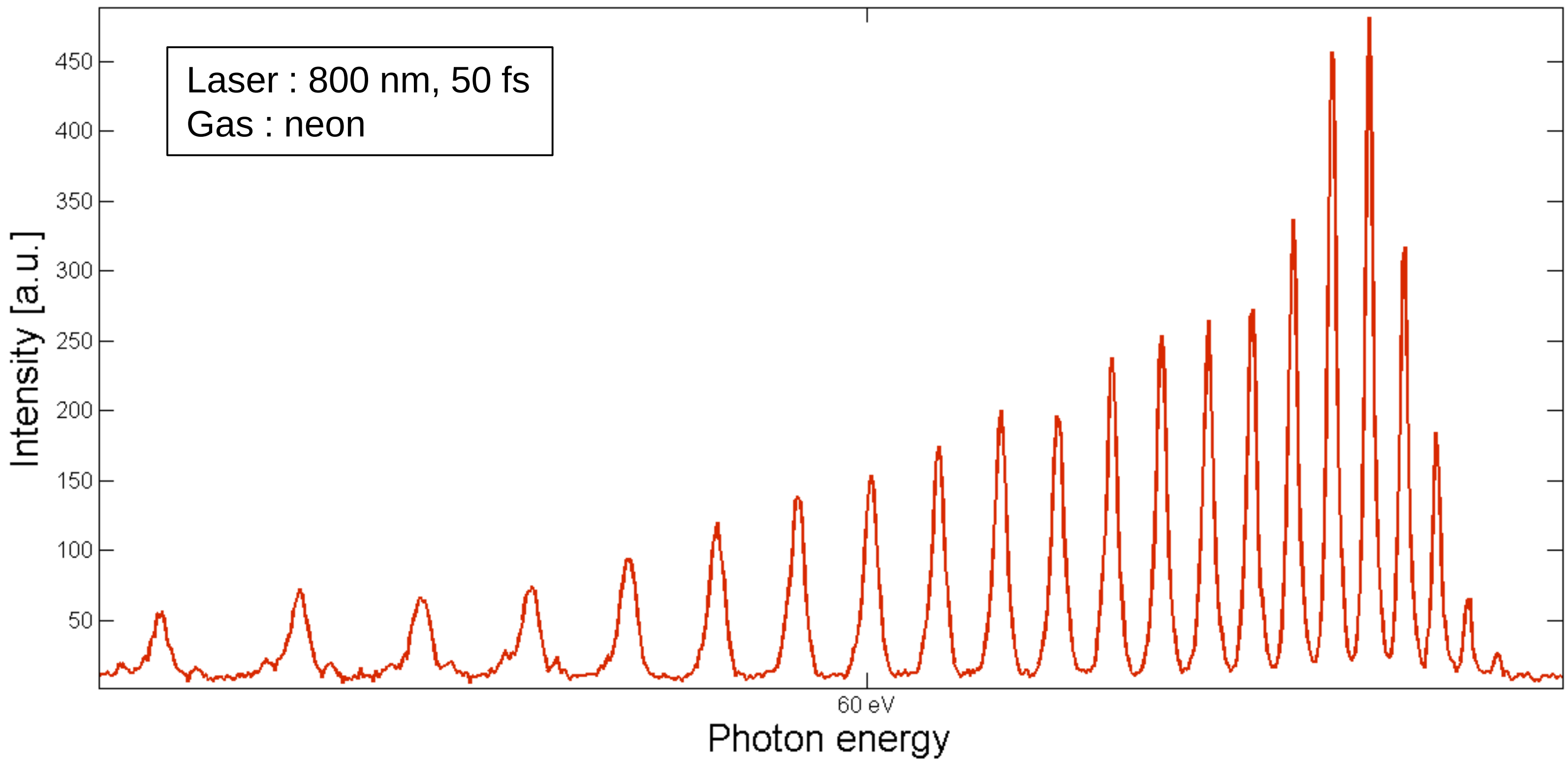
Experimental Details

High Harmonics Generation



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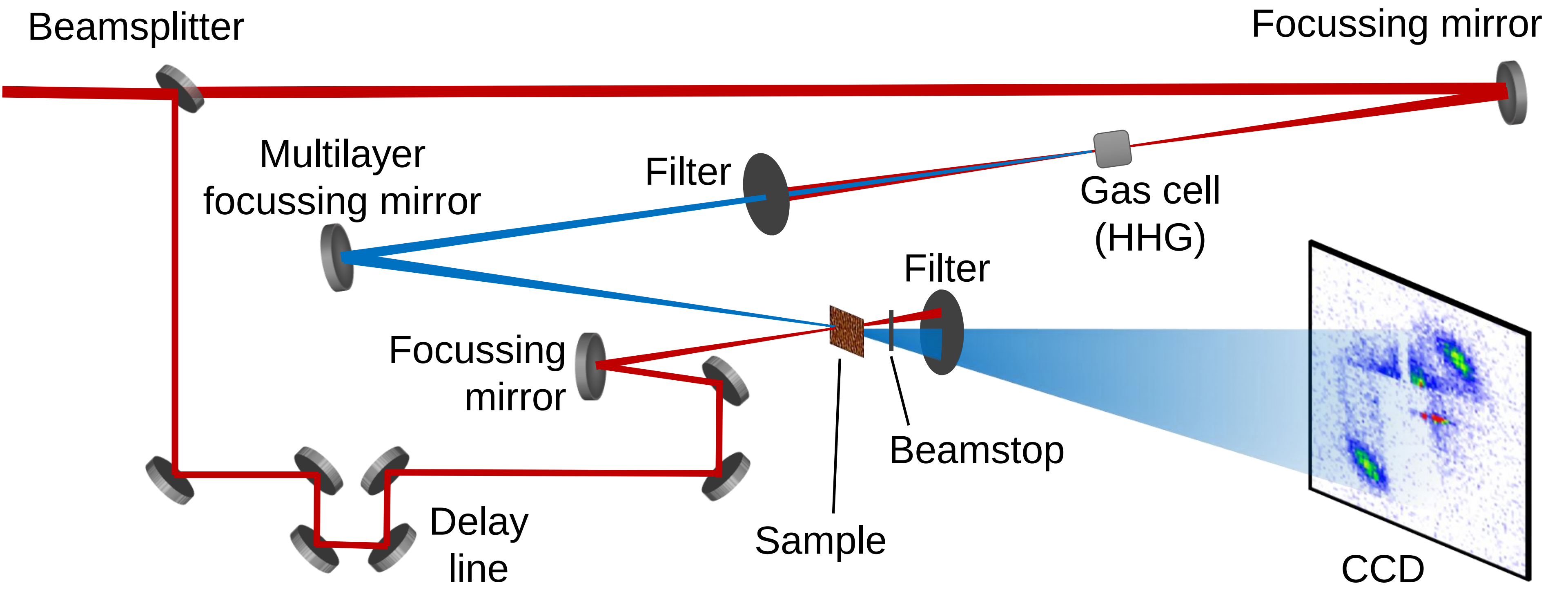
Experimental Details

Setup



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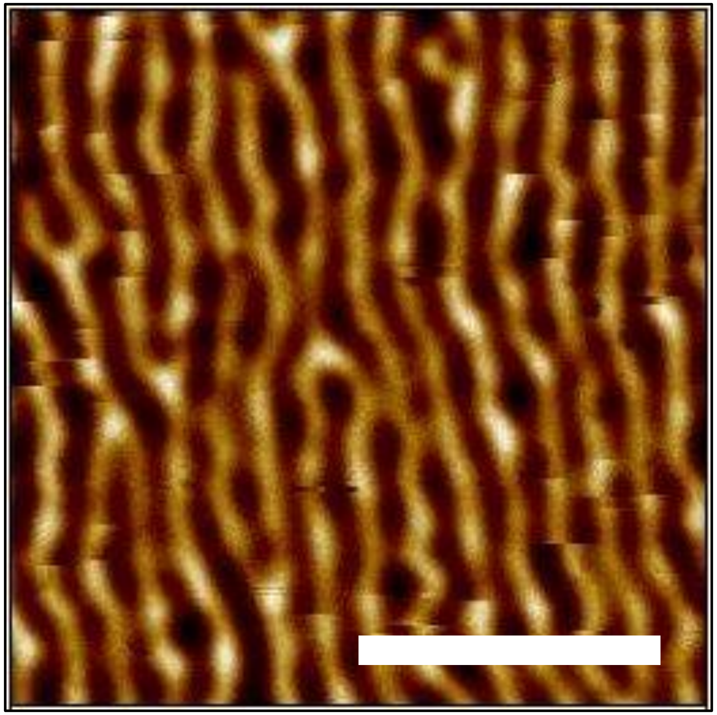
Experimental Details

Sample



Scale: 1µm

Si_3N_4(30nm) / Pt(2nm) / [Co(0.6nm) Pt(0.8nm)]$_{20}$ / Al(3nm)

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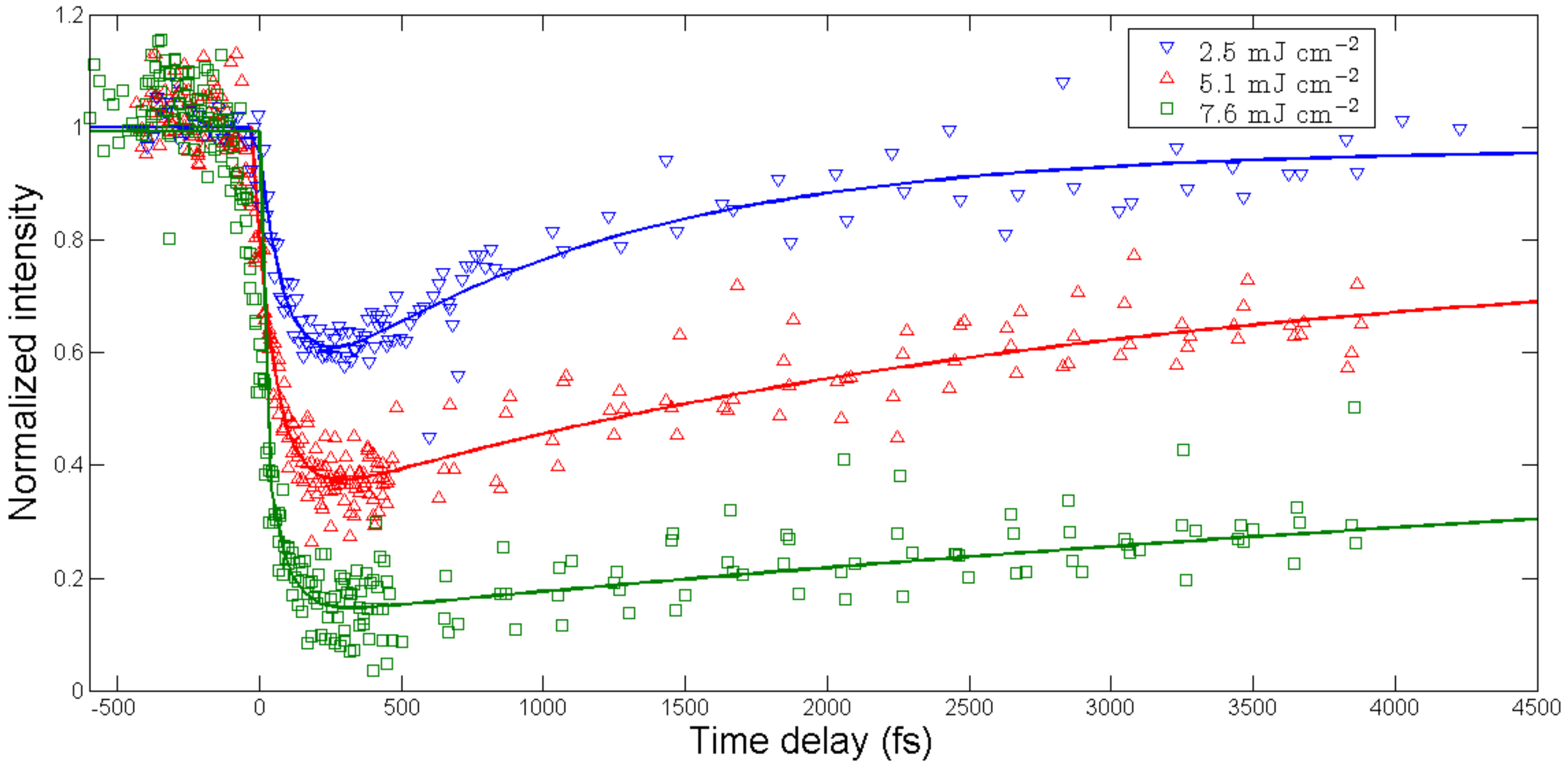
Results



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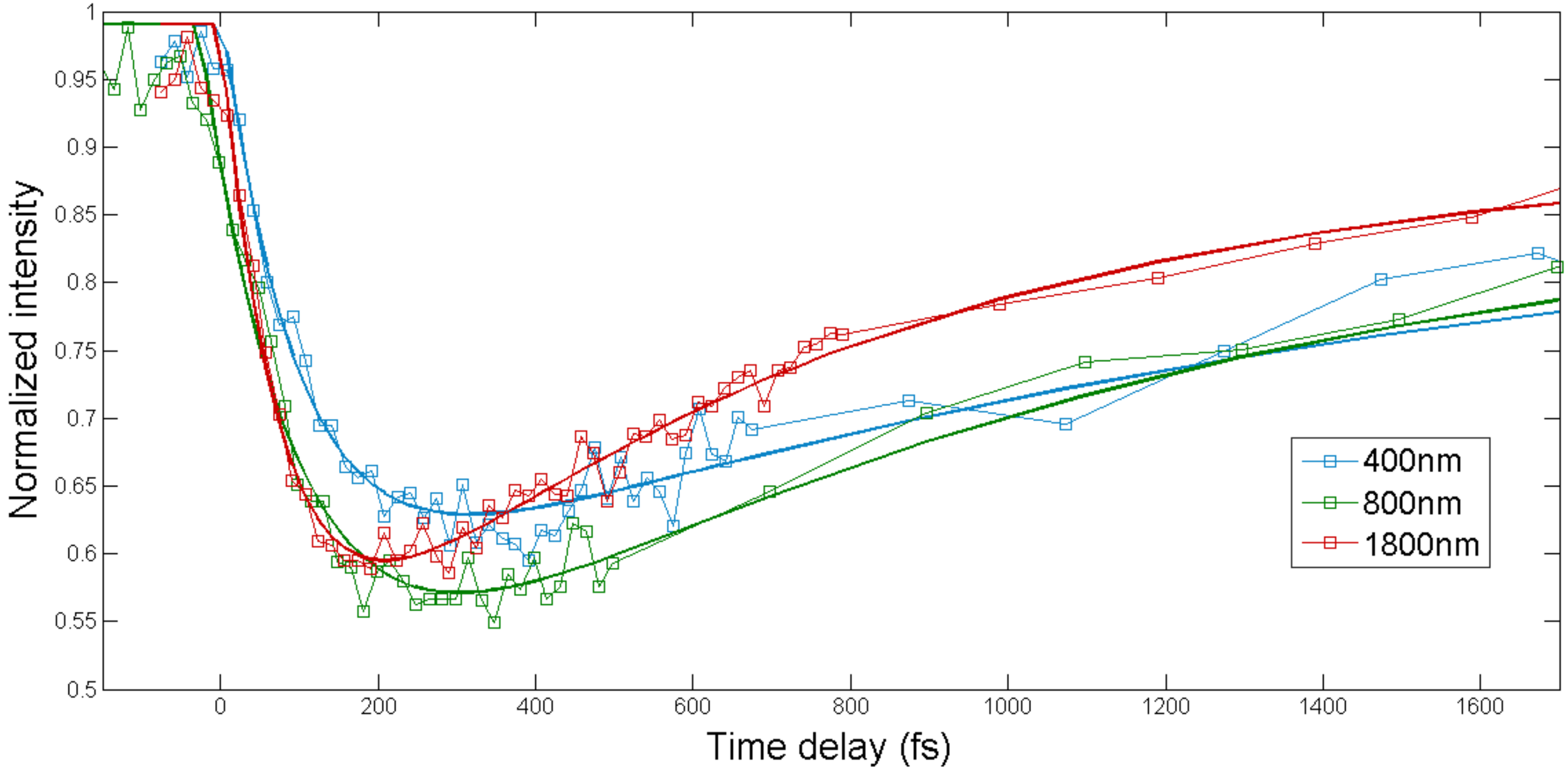
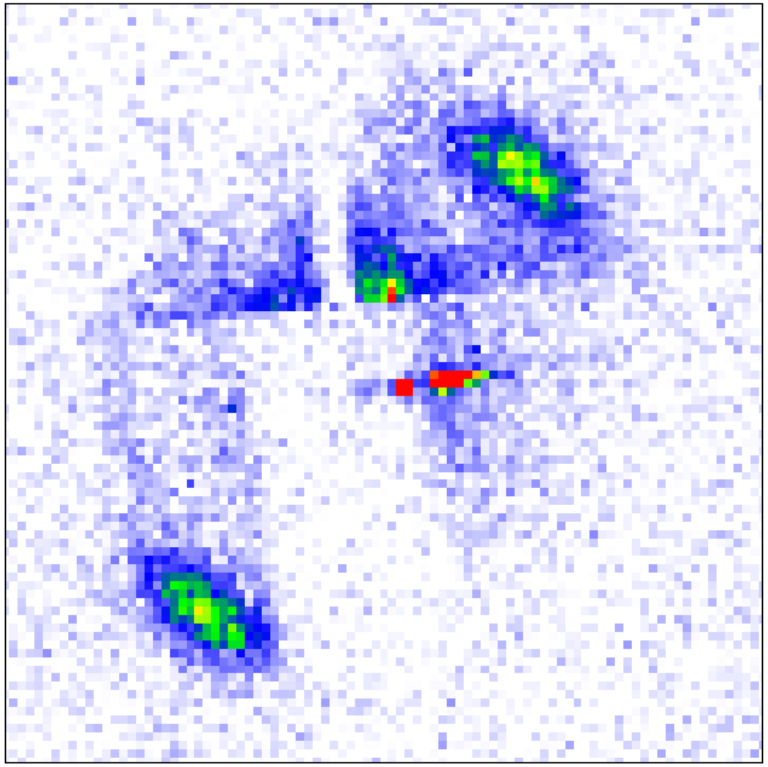
Results

Wavelength scaling



Conclusion and Prospects

- Ultrafast optical demagnetization measurements by RXSM in ALLS laboratory



- New parameters
  - Wavelength
  - Pulse duration

- Next step
  - Spatial resolution

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Acknowledgments

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Coming up

Presentation at the *Frontiers in Optics* 2017 conference (In revision)

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