# Chapter 6

# Solid-State Dynamics and Education

(http://www.eduphys.ethz.ch/)


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## 6.1 Ultrafast magnetometry using free electron laser radiation

Thomas Michlmayr, Andreas Fognini, Andreas Vaterlaus, Yves Acremann

Conventional manipulation of the magnetization involves magnetic field pulses, created by current flow through wires. Today such current pulses are typically limited to timescales of tens of picoseconds and faster manipulation of the magnetization requires a different approach. One of the forefront areas in modern magnetism is the use of ultrashort infrared or optical photon pulses to manipulate the magnetization. Since optical photons trigger the sample through electronic excitations, the fundamental questions revolve around the processes and timescales associated with energy and angular momentum transfer between the three fundamental thermodynamic reservoirs of the sample: the electronic system, the spin system and the lattice. In the past, typical experiments involve optical pump-probe schemes where the laser pump excitation is probed at variable delay time by a second laser pulse. In order to measure the magnetization of an excited ferromagnet without the need to rely on spin-orbit coupling based magneto-optical effects we built a novel setup for spin and time resolved photoemission experiments using free electron laser (FEL) radiation.

The system consists of a sample preparation UHV chamber for thin film deposition and a measurement chamber. The preparation chamber is equipped with evaporators for the magnetic material to be measured as well as a sample heating system to clean the substrates. The measurement chamber is equipped with a precise sample positioning stage, beam diagnostics as well as a pulsed magnet system, which allows for switching the sample magnetization between FEL pulse bursts. The sample will be excited by a femtosecond 800 nm laser pulse and probed by the FEL pulse, Photoelectrons will be transported to a Mott spin detector where the spin polarization is measured.

The system has been tested successfully at the Swiss Light Source in fall 2010. A spin polarization of 10 % has been measured and we are confident that the system will perform well during the FEL beamtime granted at FLASH (Hamburg) for March 2011. The beamtime will be in collaboration with the groups of Prof. W. Wurth (Hamburg), A. Foehlisch (Berlin) and J. Stöhr (Stanford)).

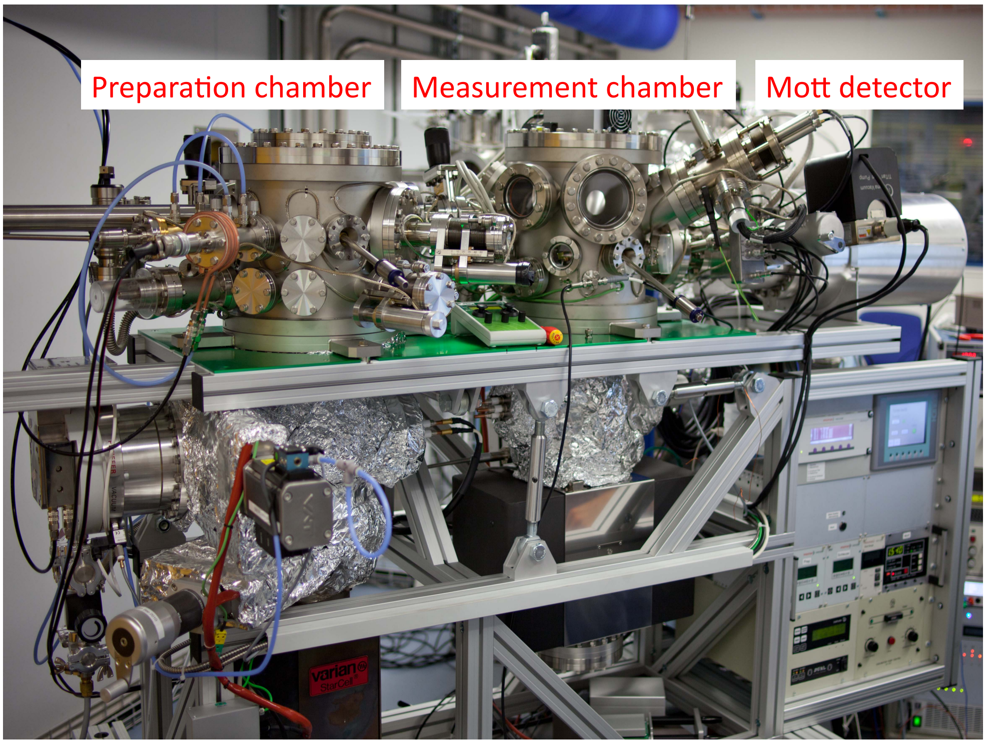


**Figure 6.1:** The new experimental system during tests at the Swiss Light Source

## 6.2 Single shot magnetic imaging

Andreas Fognini, Yves Acremann

The goal of this project is to image the dynamics of ultrafast demagnetization. As the demagnetization process may not be repeatable it is important to develop single shot imaging techniques with 100 fs temporal and 30 nm spatial resolution. Our group is part of a collaboration led by A. Scherz and J. Stöhr (SLAC, Stanford) together with the groups of J. Lüning (Paris), E. Beaurepaire (Strasbourg), G. Grübel (DESY), S. Eisebit (Berlin) and T. Rasing (Delft) working on single shot imaging using the LCLS free electron laser in Stanford.

We were present during two beamtimes in 2010. Single shot imaging of magnetic structures was demonstrated. To image the magnetic domain structure a magnetic CoPd multilayer on a SiN membrane was exposed to the FEL beam of LCLS (Stanford). The scattering pattern was recorded on an in-vacuum CCD-camera. This way a coherent diffraction pattern of the sample can be obtained. As the detector is only sensitive to the intensity, but not the phase of the scattered light the phase of the scattered wave is unknown. A point scatterer was placed next to the sample in order to provide a reference wave, which interferes with the sample wave on the detector. In this way an x-ray hologram is formed, allowing for simple image reconstruction from the measured scattering pattern.

It was possible to reconstruct the domain pattern of a sample using only a single FEL pulse. In the right conditions the sample did not get destroyed by the FEL beam, yet provided enough scattered intensity for image reconstruction.

During our beamtime a 800 nm laser pump / FEL probe experiment was performed . The goal of these experiments was to see on which length scale the magnetization breaks down after 800 nm laser excitation. We observed ultrafast demagnetization effects in the scattering pattern originating from the magnetic domain structure of the sample. So far no $q$-dependence of the demagnetization process could be detected.

## 6.3 E-Learning and teaching support

G. Schiltz

**A. Strategic activities**
In 2010 a total of 14 courses from the department have been supplemented by the learning management system Moodle. 8 introductory lectures (service and internal), 4 teacher training courses and 2 MSc lectures with a total of 2’126 students were affected. Moodle was mainly used to support the course organization and to serve as a repository for course material. For some lectures, however, supplementary pedagogical scenarios, such as self-assessment tests, formative evaluations and collaborative tasks have been set up.

Starting by autumn 2010 a special training for physics assistants was launched. The course (1CP) aims at refining the pedagogical skills that are essential to explain physics problems and to supervise practice groups. This course was offered in collaboration with the LET-unit (Lehrentwicklung und -technologie). 11 participants successfully participated in the course.

The usage and possible benefits of Classroom Response Systems (clicker) have been thoroughly tested in two introductory service lectures (A. Vaterlaus).

**B. Filep/Innovedum projects**
”Fachdidaktik II” (A. Vaterlaus) was launched in 2010 as an Innovedum focal theme project (see below).

”Real World Physics” (A. Vaterlaus) launched in 2008 was successfully completed in 2010 (see below).

”Erweiterte Physik-Vorlesungsexperimente” (B. Batlogg) has progressed in 2010. Further video material was produced and a newly developed online platform is now ready for the storage and distribution of all relevant material.

**Figure 6.2:** Assistant training

”Brückenpodcast” (W. Wegscheider) launched in 2009 was taken over by 4 more lectures. 53 audio/visual episodes were produced in 2010. The project aims at summarizing the physics lectures by a weekly published podcast, including audio and visual material. Besides bridging the weekly lectures, students used the podcast episodes for preparing their exams. The podcast was first introduced in the physics lecture of G. Dissertori in 2009 and has been positively evaluated within the project ”Selbststudium an der ETH” and during further evaluations in 2010.

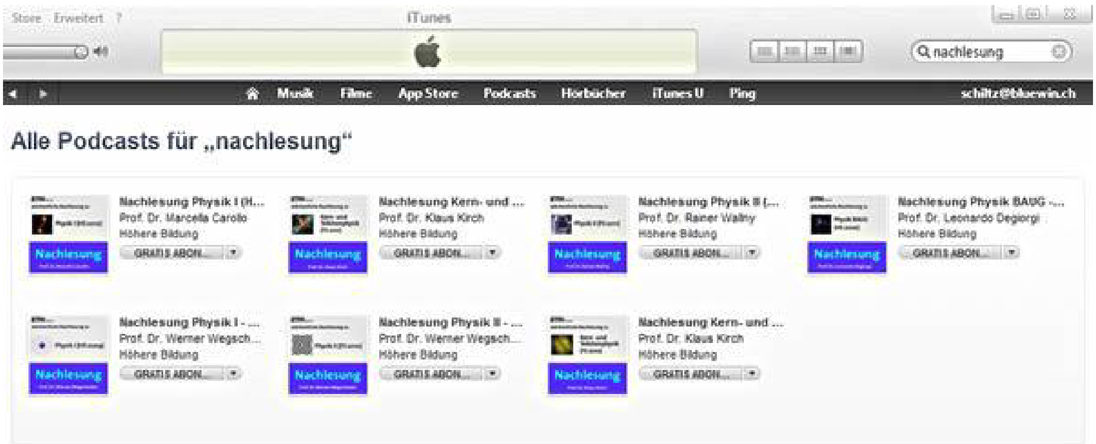


**Figure 6.3:** Brückenpodcast ”Nachlesung” available from iTunes

**C. Promotion and Network**

The teaching support activities pursued at the department have been communicated to a greater public (1 conference presentation, 1 community presentation). The effects of the current teaching support at ETH Zurich are discussed in a journal paper:
G. Schiltz, E-Learning Spezialisten an der ETH Zürich (DELIS), *Zeitschrift für Hochschulentwicklung* **5/4**, 156-165 (2010).

## 6.4 Filep & Innovedum projects

A. Vaterlaus, G. Schiltz

**"Real World Physics"** (Filep, 2008-2010)

Students from other departments attending introductory physics lectures often experience difficulties in transferring the imparted knowledge to practical problems. One of these introductory lectures was supplemented with small scale group projects where students had to describe, document and solve a physical problem. During these projects students were supported online by a senior student and they could compensate their work by an experiment unit from the "Anfänger Praktikum" (AP).

Even though students had the possibility to accredit 0,5 CP from the AP, the participation in the projects turned out to be rather moderate. However, two outstanding projects were successfully submitted as AP-experiments.

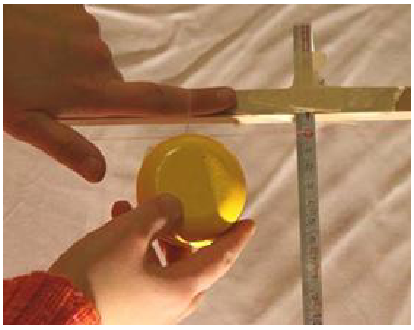

**Figure 6.4:** Project "Energy conservation in the yoyo-game"

**"Fachdidaktik II"** (Innovedum, 2010-2011)
The lecture "Fachdidaktik II" is one of the major courses in the physics teacher education program. Formerly offered as a traditional lecture, we now have supplemented this course with practical, relevant activities such as small-scale teaching projects, peer-review, discussion, and self-reflection.

The new scenario turns out to be successful and besides factual expertise students are efficiently acquiring methodical, social and personal competencies.