First Soft X-rays Explore Ultrafast Magnetic Behaviors

July 19 2010, by Lauren Rugani

(PhysOrg.com) -- The first user experiments on the Soft X-ray instrument at the Linac Coherent Light Source wrapped up last week. Research led by Andreas Scherz, a physicist at the Stanford Institute for Materials and Energy Science, and Jan Lüning from the University Pierre and Marie Curie in France looked to explain on the nanoscale how magnetic fields switch between "up" and "down" states -- a key process used to store data in computers.

Researchers have been investigating this phenomenon since 1996 with a variety of experimental techniques. X-rays have been used to probe magnetic films with a resolution of tens of nanometers, while optical methods have been used to observe ultrafast demagnetization on the macroscale. But examining such magnetic behaviors on the nanoscale remained difficult.

Enter the SXR. The instrument—the second to be commissioned by the LCLS—delivers ultra-short, ultra-bright bursts of X-ray laser light that can be used to image events on the smallest and fastest scales. Previous research showed that quick pulses of infrared light can momentarily heat and destroy the internal organization of permanently magnetic materials. Scherz, Lüning and their colleagues knew that using the high-intensity, femtosecond X-ray pulses from the SXR to probe such a disordered sample could provide information about the length scales at which magnetization and demagnetization occur.

Although the researchers submitted separate proposals for the SXR, their

objectives were so similar that they decided to combine their allotted beam time into one collaborative effort. In all, more than 30 users from ten different international institutions took part in the inaugural experiments.

"When you run an experiment that requires a lot of analysis and feedback, you want to have a big group," Lüning said. The group members worked around the clock to interpret the influx of data, and having a multitude of minds was beneficial in the ensuing discussions.

Over the course of beamtime, the team was able to answer many of the questions they brought to the SXR; they also gathered unexpected information, including the relationship between the intensity of the X-rays and the electronic damage caused to the test samples. The experiments opened up new questions about whether a magnetic material can completely "forget" its orientation after being disordered, and if a new orientation could be constructed in its place.

"It is exciting when things happen that we don't foresee," Lüning said. "We learned new things, we observed phenomena that we didn't anticipate, and we have more questions to explore." Some members of the group will return to SXR in December with similar experiments, while others have submitted proposals for next year's run that will follow up on analysis from the current data and explore new topics.

"We can't wait to come back. We have a set of questions we can only address with the SXR," Scherz said.

Provided by SLAC National Accelerator Laboratory