Magnetism catches the wave -
Direct imaging of magneto dynamic modes induced by strain waves

Dr. Michael Foerster, ALBA Synchrotron

The magnetoelastic effect or inverse magnetostriction is the change of magnetic properties caused by an elastic deformation (strain). For instance, the magnetic anisotropy, i.e. a preferred magnetic direction, can be controlled by uniaxial strain generated by a piezo- or ferroelectric phase. This approach has attracted much interest due to its potential to write small magnetic elements, as used in sensors and magnetic data storage, by an electric voltage rather than current, avoiding energy losses. However, so far practical demonstrations were realized on timescales far too slow for most applications.
We have used propagating strain waves (Surface Acoustic Waves, SAW) in $LiNbO_3$ substrates to generate fast strain in Ni magnetic nanostructures. When synchronizing the SAW excitation with the ALBA Synchroton radio frequency (500 MHz), snapshots of the propagating SAW can be acquired by X-ray PhotoEmission Electron Microscopy (XPEEM), since it is sensitive to the piezoelectric part of the SAW. Combined with XMCD magnetic contrast, the magnetic state of the Ni patterns can be simultaneously imaged (XMCD-PEEM) for any specific phase with respect to the SAW at a temporal resolution below 100 ps. We found that the magnetoelastic effects on the subnanosecond timescale are as efficient as for the static strain case. Different delays (100-300 ps) of the magnetic response to the strain wave were measured, depending on the magnetic configuration. The delays are related to the intrinsic magnetization dynamics of the Ni patterns. Thus it is shown that while the magnetoelastic effect itself is very fast, for the speed of a potential device the magnetization state has to be properly designed.