Magnetoacoustic waves: Towards a new paradigm of on-chip communication

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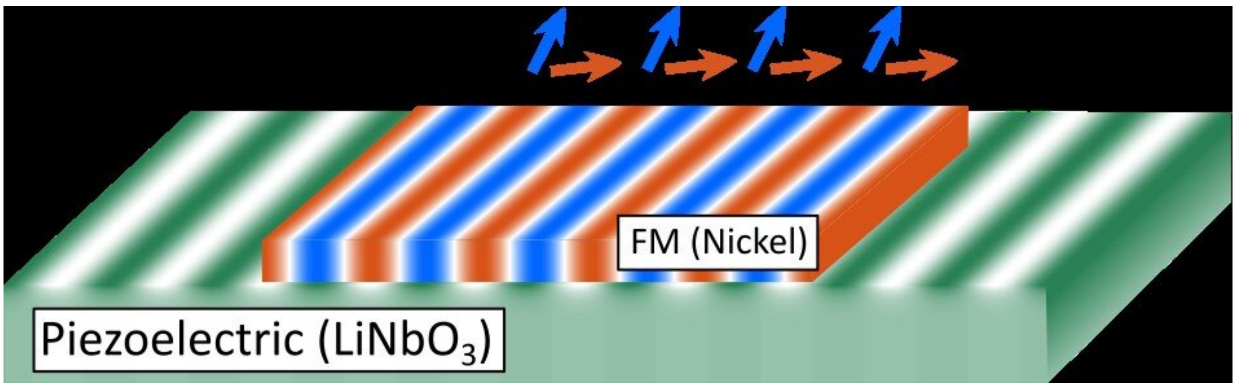

Scheme of the strain caused by the surface acoustic waves (SAWs) in the piezoelectric (in green color scale) and magnetic modulation in the ferromagnetic material (in orange-cyan color scale). Credit: B. Casals et al.

Researchers have observed directly and for the first time magnetoacoustic waves (sound-driven spin waves), which are considered as potential information carriers for novel computation schemes. These waves have been generated and observed on hybrid magnetic/piezoelectric devices. The experiments were designed in a collaboration between the University of Barcelona (UB), the Institute of Materials Science of Barcelona (ICMAB-CSIC) and the ALBA Synchrotron. The results show that magnetoacoustic waves can travel over long distances—up to centimeters—and have larger amplitudes than expected.

The observation of the magnetization waves was performed in a nickel ferromagnetic thin film, which was excited by a deformation wave (called surface acoustic wave, SAW) originated in a piezoelectric substrate layer below the nickel film. Although clear interaction between acoustic waves and magnetization dynamics has been reported in several systems, thus far, no direct observation of the underlying magnetic excitations existed, providing a quantification of both time and space.

Now researchers have published in *Physical Review Letters* their findings: "We designed an experiment ad hoc to image and quantify the magnetization dynamics generated by surface acoustic waves (SAW). The results clearly show that magnetization waves exist at distinct frequencies and wavelengths and that it is possible to create wave interferences," explains Ferran Macià, leader of the project at the UB and ICMAB.

The experiments show interference patterns of magnetization waves and provides new avenues for manipulation of these waves at room temperature "Our magnetization waves are coupled to the acoustic waves and thus, can travel long distances and have larger amplitudes than spin waves," explains Michael Foerster, beamline scientist of CIRCE-PEEM at ALBA. Such large-amplitude, long-distance waves could be well-suited for carrying information, processing data, or driving small motors.

The generation of magnetization dynamics through acoustic waves has attracted interest because it has some advantages over magnetic field induced excitations, such as more energy efficiency, larger spatial extension, or match of wavelengths.

The experiments were performed using PEEM (photoemission electron microscopy) at the CIRCE beamline at the ALBA Synchrotron to image the magnetization waves, which were synchronized with the synchrotron light pulses. "As waves are dynamic objects, they were imaged with stroboscopic snapshots thanks to this synchronization. The X-ray magnetic circular dichroism (XMCD) effect was used to obtain magnetic contrast in the images," explains Macià.

More information: Blai Casals et al, Generation and Imaging of Magnetoacoustic Waves over Millimeter Distances, *Physical Review Letters* (2020). DOI: 10.1103/PhysRevLett.124.137202

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