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"Magnonic nanoantennas" demonstrated: Optically-inspired computing with spin waves one step closer

BROOKLYN, New York, and MILAN, Italy, Thursday, May 5, 2020 – A cover article in the journal *Advanced Materials* demonstrates a new methodology for generating and manipulating spin waves in nanostructured magnetic materials. This work opens the way to developing nano-processors for extraordinarily quick and energy efficient analog processing of information.

The discovery was the result of a collaboration among a research group headed by NYU Tandon School of Engineering Professor of Chemical and Biomolecular Engineering Elisa Riedo; the magnetism group in the Physics Department at Politecnico di Milano, comprising Edoardo Albisetti, Daniela Petti and Riccardo Bertacco; Silvia Tacchi of the Istituto Officina dei Materiali of the Italian National Research Council (CNR-IOM) in Perugia; the Physics and Geology Department at University of Perugia; and the PolLux Beamline at PSI, in Villigen, Switzerland.

Spin waves, also known as "magnons", are analogous to electromagnetic waves for magnetism, and propagate in materials such as iron in a way that is similar to that of waves in the ocean. Compared to electromagnetic waves, magnons are characterized by unique properties that make them ideal for developing miniaturized "analog" computing systems that will be much more efficient than the digital systems currently available.

Until now, modulating spin waves at will was extremely complex. The article published in *Advanced Materials* on March 5, 2020 presents a new type of emitters, called "magnonic nanoantennas," which allow for the generation of spin waves with controlled shape and propagation. For example, it is possible to obtain radial wavefronts (such as those generated by throwing a stone into a pool of water), or planar wavefronts (as ocean waves on the beach), as well as creating focused directional beams. The article also demonstrates that, by using multiple nanoantennas simultaneously, interference figures can be generated "on command," which is a necessary condition for developing analog computing systems.

The nanoantennas were realized by employing the TAM-SPL technique (developed at Politecnico di Milano in collaboration with Riedo's group), which allows for the manipulation of the magnetic properties of the materials at the nanoscale. Specifically, the nanoantennas consist of minuscule "ripples" in the magnetisation of the material (called "domain walls" and "vortices") that, when set in motion by an oscillating magnetic field, emit spin waves. Given that the spin waves' properties are linked to the type and peculiar characteristics of these ripples, controlling them very accurately allowed to modulate the emitted waves as never before.

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The article, entitled "Optically-inspired nanomagnonics with nonreciprocal spin waves in synthetic antiferromagnets" is available on the website of *Advanced Materials*: https://onlinelibrary.wiley.com/doi/10.1002/adma.201906439

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