Speed of magnetic domain walls found to be fundamentally limited

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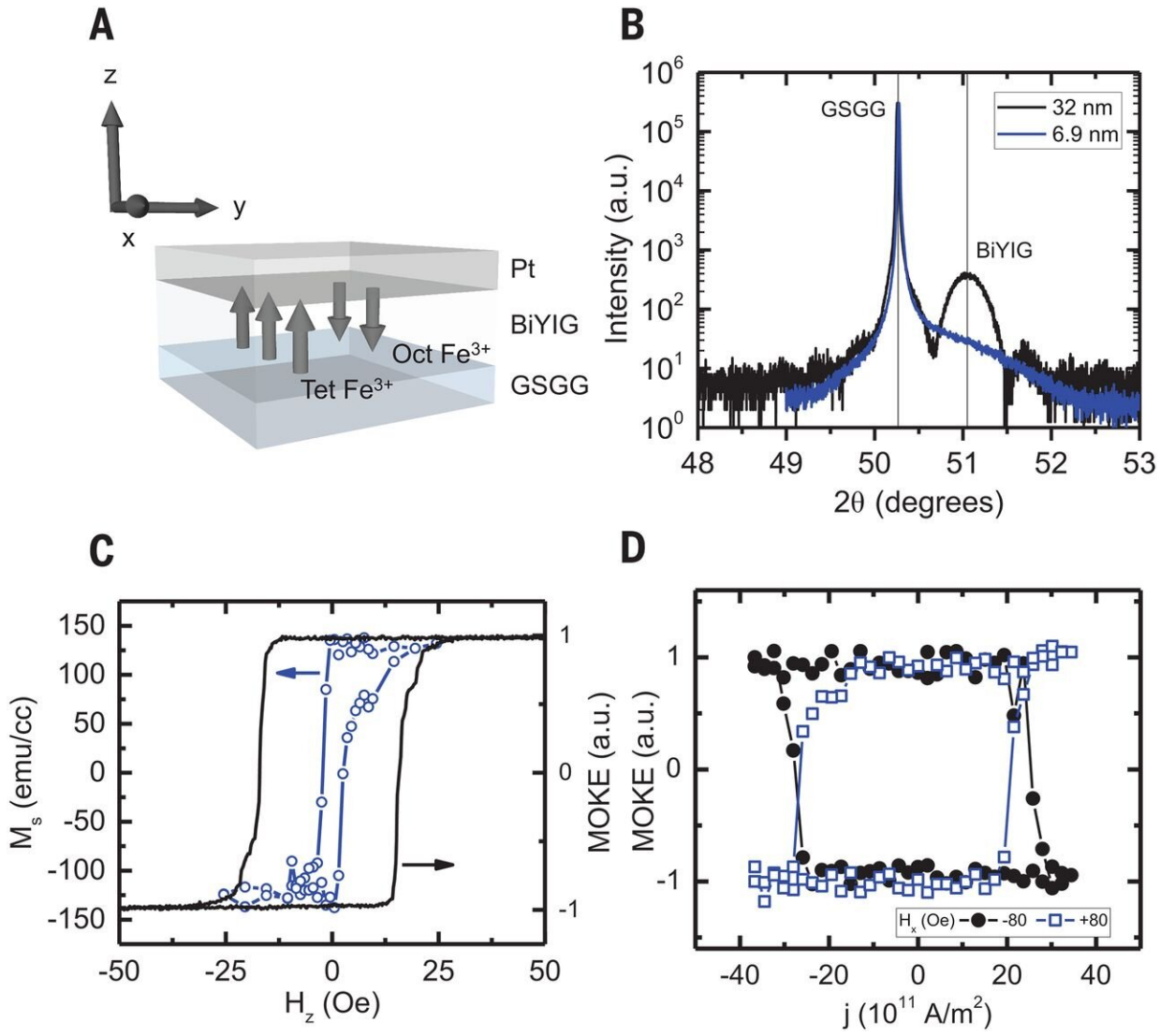

Structural and magnetic characterization. Credit: *Science* , DOI: 10.1126/science.aba5555

A team of researchers from MIT and several institutions in Korea has found that the speed of magnetic domain wall movement is fundamentally limited. In their paper published in the journal *Science*, the group describes testing a theory regarding the maximum speed of domain walls to prove them correct. Matthew Daniels and Mark Stiles with the National Institute of Standards and Technology in the U.S. have published a Perspective piece outlining the work by the researchers in the same journal issue and sum up the implications of their findings.

One of the basic tenets of Einstein's theory of special relativity is that there is no particle that can travel faster than the speed of light. In this new effort, the researchers have found a similar boundary for magnetic domain walls.

Materials that are magnetic have domains in which ordered spins are separated from one another by boundaries known as domain walls. Prior research has shown that such walls can be moved by applying an electric current. This particular aspect of magnetic materials has formed the basis of research on racetrack memory. And because the speed of movement of the domain walls determines the speed of the memories created using them, scientists have been pushing them faster and faster. Logic suggests that there must be a limit to how fast the domain walls can be pushed, however, thus establishing a limit to how fast such memories can operate. In this new effort, the researchers have found that fundamental limit.

As Daniels and Stiles note, domain walls behave like objects embedded in a material and thus can be moved not just forward, but back, as well. This can be done by applying magnetic and electronic fields. This is how memory devices are made. Theory (the Lorentz invariance of domain walls) has suggested that the limiting factor in moving domain walls is

the spin wave speed associated with a magnetic material. To test this idea, the researchers conducted a series of trials in which they moved domain walls using variable electric and magnetic fields to their saturation point. They found that as they did so, the domain wall speed asymptotically approached the theoretically predicted value of the spin speed for the magnetic material—which turned out to be approximately 5 km/s, the fundamental speed limit.

More information: Relativistic kinematics of a magnetic soliton, *Science*, 18 Dec 2020: Vol. 370, Issue 6523, pp. 1438-1442, DOI: 10.1126/science.aba5555 , science.sciencemag.org/content/370/6523/1438