Engineers achieve significant breakthrough in spin wave based information processing technology

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Conventional electronic devices make use of semiconductor circuits and they transmit information by electric charges. However, such devices are being pushed to their physical limit and the technology is facing immense challenges to meet the increasing demand for speed and further miniaturisation. Spin wave based devices, which utilise collective excitations of electronic spins in magnetic materials as a carrier of information, have huge potential as memory devices that are more energy efficient, faster, and higher in capacity.

While spin wave based devices are one of the most promising alternatives to current semiconductor technology, spin wave signal propagation is anisotropic in nature – its properties vary in different directions – thus posing challenges for practical industrial applications of such devices.

A research team led by Professor Adekunle Adeyeye from the Department of Electrical and Computer Engineering at the NUS Faculty of Engineering, has recently achieved a significant breakthrough in spin wave information processing technology. His team has successfully developed a novel method for the simultaneous propagation of spin wave signals in multiple directions at the same frequency, without the need for any external magnetic field.

Using a novel structure comprising different layers of magnetic materials to generate spin wave signals, this approach allows for ultra-low power operations, making it suitable for device integration as well as energy-efficient operation at room temperature.

"The ability to propagate spin waves signal in arbitrary directions is a key requirement for actual circuitry implementation. Hence, the implication of our invention is far-reaching and addresses a key challenge for the industrial application of spin wave technology. This will pave the way for non-charge based information processing and realisation of such devices," said Dr Arabinda Haldar, who is the first author of the study and was formerly a Research Fellow with the Department at NUS. Dr Haldar is currently an Assistant Professor at Indian Institute of Technology Hyderabad.

The research team published the findings of their study in the scientific journal *Science Advances* on 21 July 2017. This discovery builds on an earlier study by the team that was published in *Nature Nanotechnology* in 2016, in which a novel device that could transmit and manipulate spin wave signals without the need for any external magnetic field or current was developed. The research team has filed patents for these two inventions.

"Collectively, both discoveries would make possible the on-demand control of spin waves, as well as the local manipulation of information and reprogramming of magnetic circuits, thus enabling the implementation of spin wave based computing and coherent processing of data," said Prof. Adeyeye.

Moving forward, the team is exploring the use of novel magnetic materials to enable coherent long distance spin wave signal transmission, so as to further the applications of spin wave technology.

More information: Arabinda Haldar et al. Isotropic transmission of magnon spin information without a magnetic field, *Science Advances* (2017). DOI: 10.1126/sciadv.1700638

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