Control of spin-wave scattering on disc nano-resonators in vortex magnetisation state

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Artificial neural networks (ANN) have seen remarkable advancements in recent years, significantly impacting science and everyday life. However, training and operating software-based ANNs demand substantial energy resources. One promising solution is implementing ANNs as specialized physical devices optimized for specific tasks, such as speech recognition. This concept can be realized using wave physics, where information encoded in waves is processed through scattering on a resonator matrix [1]. Wave physics enables the use of spin waves (SWs), disturbances in a medium's magnetization, which offer lower energy consumption and better miniaturization prospects [2].

In this work, we examine the scattering properties of disc-shaped, ferromagnetic nano-resonators with magnetization in a vortex state placed on the top of the yttrium iron thin film, focusing on the azimuthal scattering of SWs. We investigate how the resonators' geometry, their magnetic vortex states and their relative positions influences the forward scattering of the incident SWs and formation an interference pattern. Additionally, we explore nonlinear effects accompanying SW scattering, such as excitation of higher harmonics and amplitude foldover with frequency change. Our findings demonstrate flexibility in controlling SW scattering and accessing nonlinear effects. In this work we analyse usefulness of the nano-resonators as a building block of future magnonics-based ANNs.

Acknowledgements: The research leading to these results has received funding from the Polish National Science Centre project No. 2022/45/N/ST3/01844 and EU Research and Innovation Programme Horizon Europe (HORIZON-CL4-2021-DIGITAL-EMERGING-01) under grant agreement no. 101070347 (MANNGA).

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