Magnon Scattering by a Driven Space-Time Magnonic Crystal

P. Gruszecki,[1] N. Trager,[2] F. Lisiecki,[3] F. Gross,[2] M. Weigand,[2,4] H. Glowinski,[3] P. Kuswik,[3] J. Dubowik,[3] G. Schutz,[2] and M. Krawczyk[1]

[1]*Institute of Spintronics and Quantum Information, Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznanskiego 2, 61-614 Poznan, Poland*

[2]*Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany*

[3]*Institute of Molecular Physics, Polish Academy of Sciences, Mariana Smoluchowskiego 17, 60-179 Poznan, Poland*

[4]*Helmholtz-Zentrum Berlin für Materialien und Energie, Albert-Einstein-Str. 15, 12489 Berlin, Germany*

The breaking of continuous spatial translational symmetry is the most important indicator of' crystal formation, whereas the breaking of the translational symmetry in time is fundamental for temporal crystals. The idea of systems with broken translational symmetry in space and time, so-called Space-Time Crystals, was proposed by F. Wilczek in 2012 [1].

Using scanning transmission X-ray microscopy we experimentally demonstrate at room-temperature and explain with micromagnetic simulations, the formation of a dynamical magnetic pattern characterized by a periodicity in both time and space in a thin permalloy stripe pumped by a spatially uniform microwave field [2]. Such a system can be considered as a driven space-time magnonic crystal (STMC). Moreover, we demonstrate an interaction of magnons with this STMC, resulting in the appearance of 100 nm long spin waves that are much shorter than the waves expected from the dispersion relation of the uniformly magnetized permalloy stripe at the pumping frequency. We show that this short wave originates from the second Brillouin zone of the magnonic band structure of the driven STMC. This founding clearly confirms the dynamical formation of the periodicity in space in a homogeneous ferromagnetic element.

References:

[1] Wilczek F, Quantum Time Crystals, Phys. Rev. Lett. 109, 160401 (2012).

[2] Träger N, Gruszecki P, Lisiecki F, Groß F, Förster J, Weigand M, Głowiński H, Kuświk P, Dubowik J, Schütz G, Krawczyk M. Real-Space Observation of Magnon Interaction with Driven Space-Time Crystals. Physical Review Letters 126, 057201 (2021).

The research has received partially funding from the Polish National Science Centre project No. 2019/35/D/ST3/03729.