



Thursday, 09<sup>st</sup> February 2023, 17.15 h  
Lecture Hall III, Department of Physics, Garching

Approaching machine learning with nonlinear  
magnonic hardware

Helmut Schultheiss

*Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany, and  
Fakultät Physik, Technische Universität Dresden, Dresden, Germany*

**Abstract:**

Combining spin waves and spin textures for neuromorphic computing seems like a wonderful thing to do. Numerous publications in the last couple of years demonstrated possible schemes for unconventional computing. The success is based on the nonlinearity of spin waves and the incredible density and robustness of spin textures. Bringing both together, nonlinear spin waves in spin textures, is not just a simple advancement of magnonics, but it also surprises with some unexpected phenomena.

We demonstrate recognition of pattern sequences in a serial data stream in the microwave frequency range using nonlinear spin waves in a single magnetic vortex [1]. The approach of multiplexing in the frequency domain in a quantized system with delocalized spin waves circumvents the standard problems of magnonics such as high spatial decay and limited lifetime. Especially for brain-inspired schemes, which rely on many connections between nonlinear nodes, the transitions between different spin-wave eigenmodes by stimulated magnon-magnon scattering [2] is unexplored territory. The effective number of nonlinear nodes can be extended by generating spin-wave frequency combs [3], which spontaneously appear in magnetic vortices by the mutual interaction of the vortex core gyration and the spin-wave eigenmodes.

**References**

- [1] Lukas Körber, Christopher Heins, Tobias Hula, Joo-Von Kim, Helmut Schultheiss, Jürgen Fassbender, Katrin Schultheiss: **Pattern recognition with a magnon-scattering reservoir**, arXiv:2211.02328.
- [2] Lukas Körber, Katrin Schultheiss, Tobias Hula, Roman Verba, Jürgen Faßbender, Attila Kákay, Helmut Schultheiss: **Nonlocal stimulation of three-magnon splitting in a magnetic vortex**, PRL 125, 207203 (2020)
- [3] Tobias Hula, Katrin Schultheiss, Francisco José Trindade Goncalves, Lukas Körber, Mauricio Bejarano, Matthew Copus, Luis Flacke, Lukas Liensberger, Aleksandr Buzdakov, Attila Kákay, Mathias Weiler, Robert Camley, Jürgen Fassbender, Helmut Schultheiß: **Spin-wave frequency combs**, APL 121, 112404 (2022)

*There will be coffee, tea, and cookies in front of the lecture hall at 17.00 h*