
Real-Space Observation of Magnon interaction with Driven Space-Time Crystals

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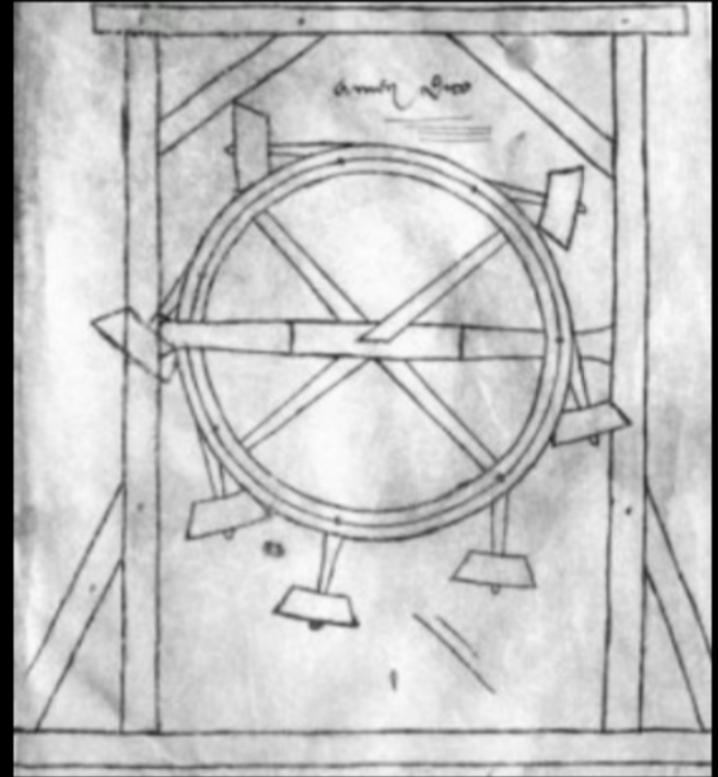
presented by Lukas Vogl

Content

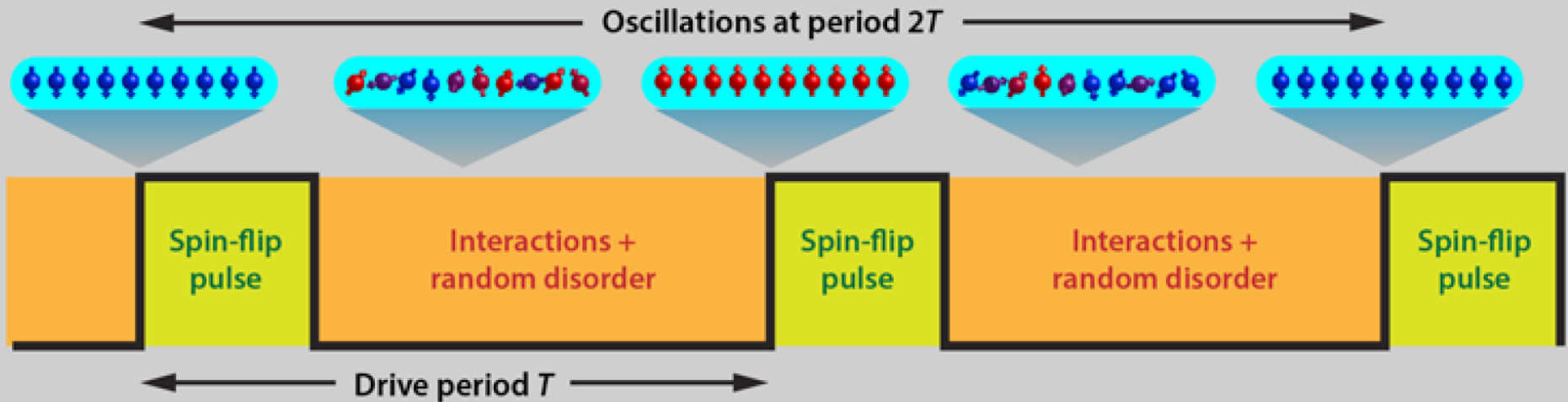
- General concept of time crystals
- Magnonic crystals
- Experimental setup
- Measurement technique
- Results and analysis
- Conclusion

General Concept of Time crystals

- Parity between space and time
4D Space-Time
 - Translational symmetry breaking in 3D Space - Crystals
- > time crystals?
- Oscillation uncorrelated to any external time-dependent force

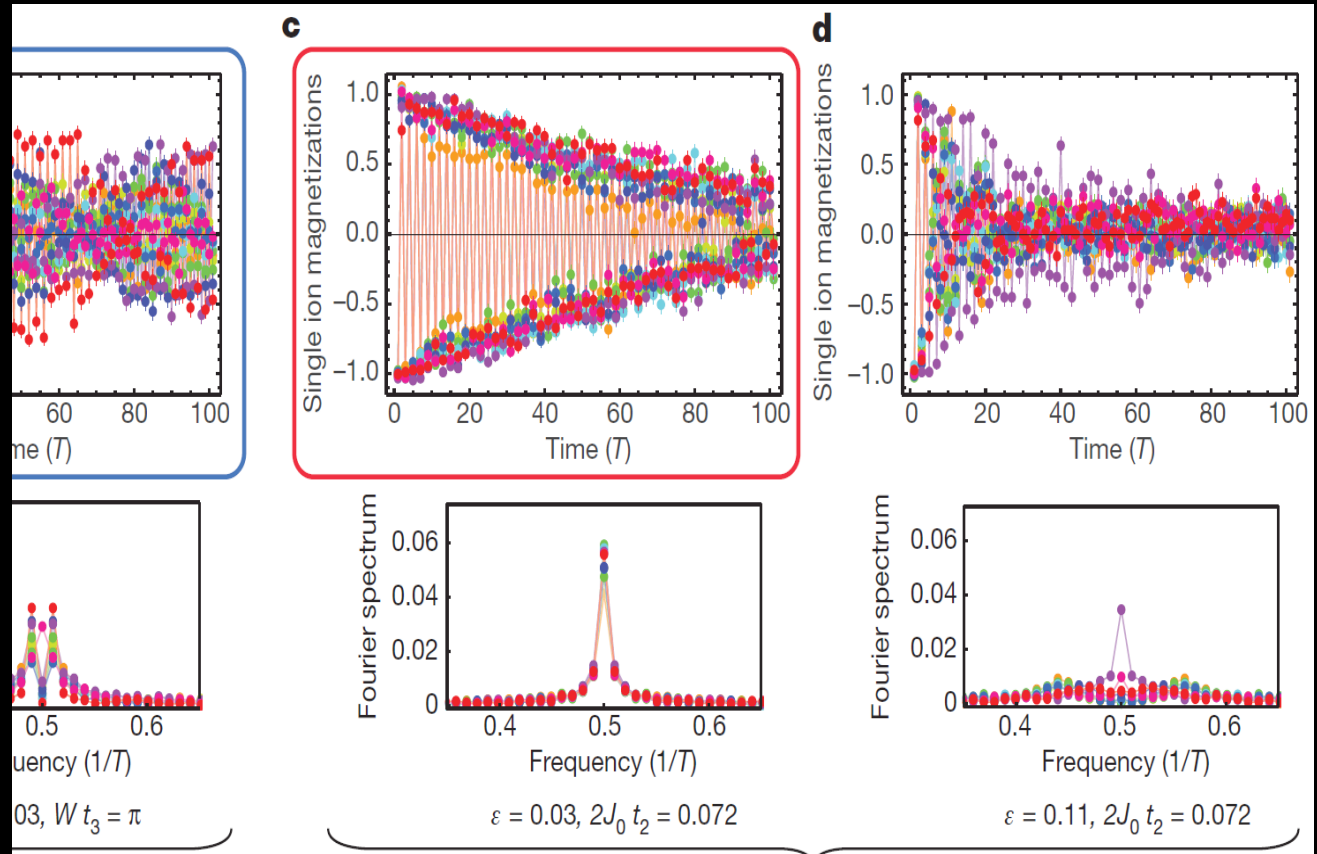


General Concept of Time crystals



General Concept of Time crystals

- 1D spin-chain of Yb ions



General Concept of Time crystals

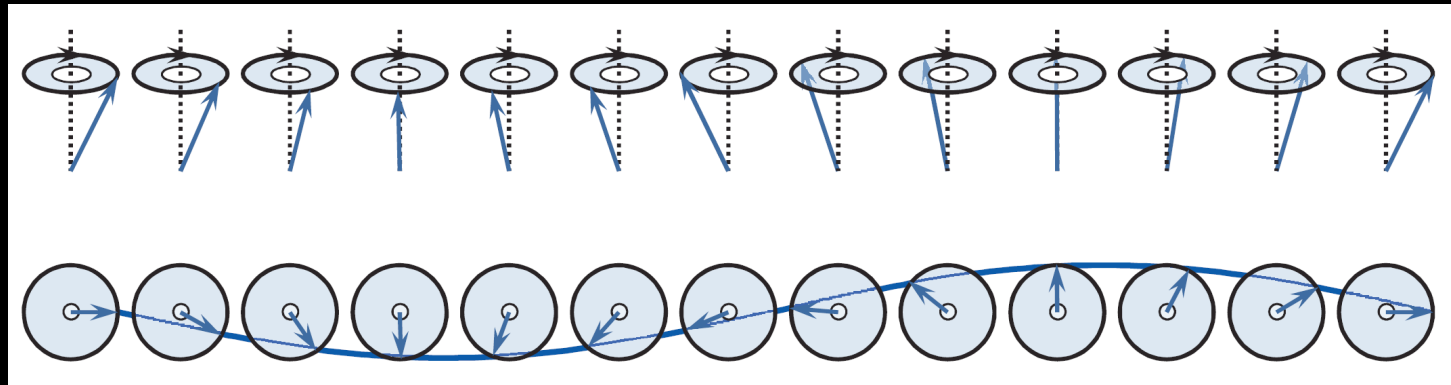
- Translational symmetry breaking in Space and Time
- Only in extremely small, quantum systems, very low temperature
- This work will unite time crystal concepts with magnonic crystals to form classical magnonic space-time-crystal

Magnonic Crystals

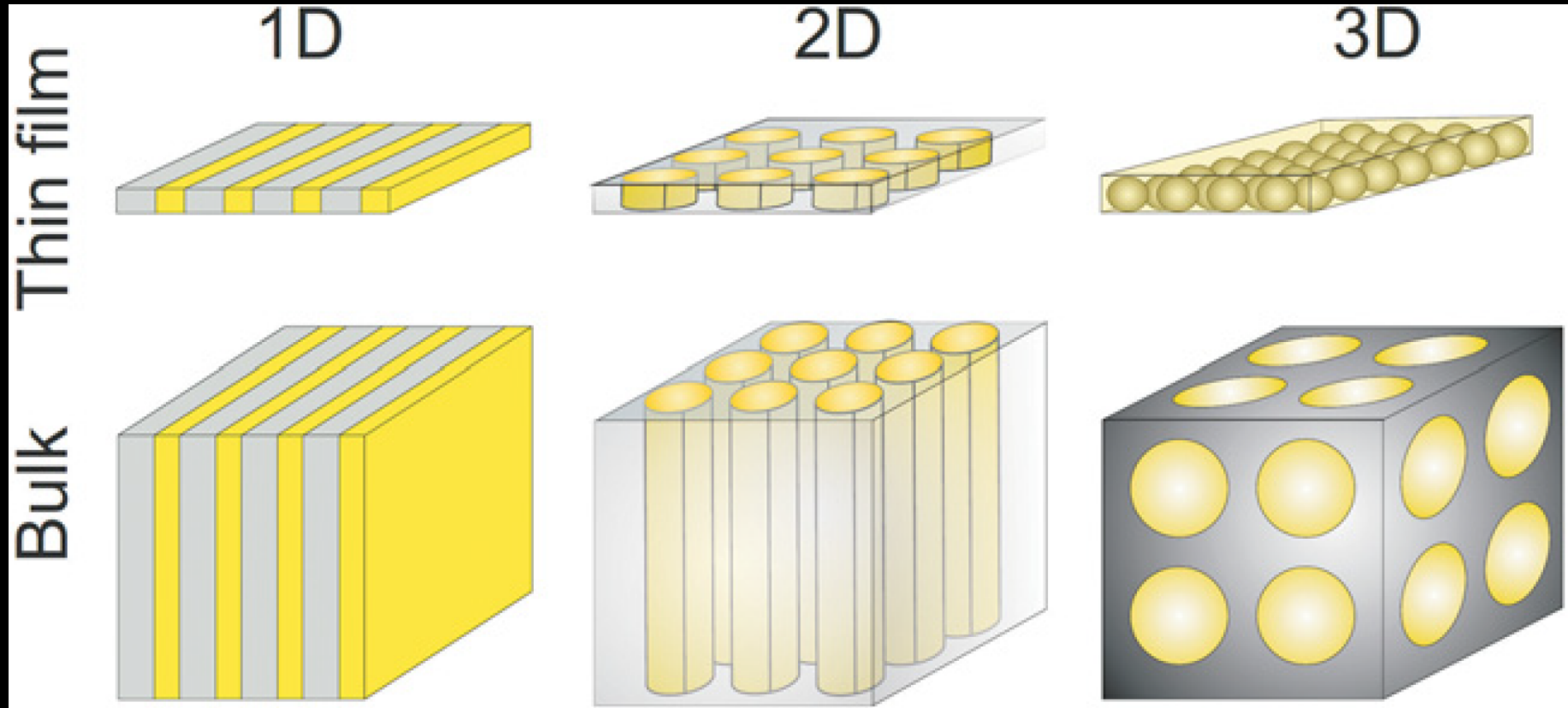
- Spin-waves:

A spin wave is a propagating disturbance in the ordering of a magnetic material. Wikipedia

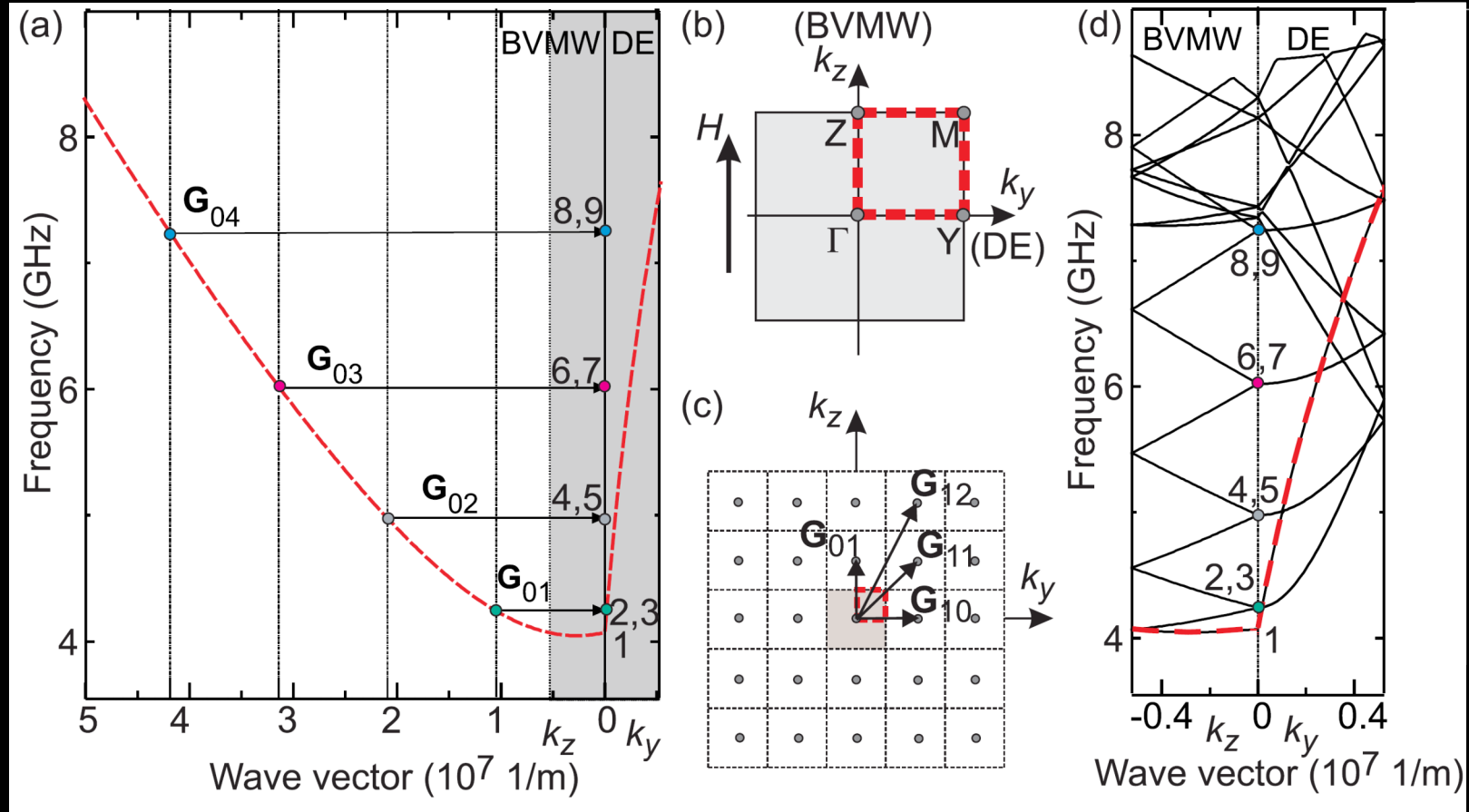
- Magnon: quantized spin-wave
 - spin-1 ; bosonic behavior



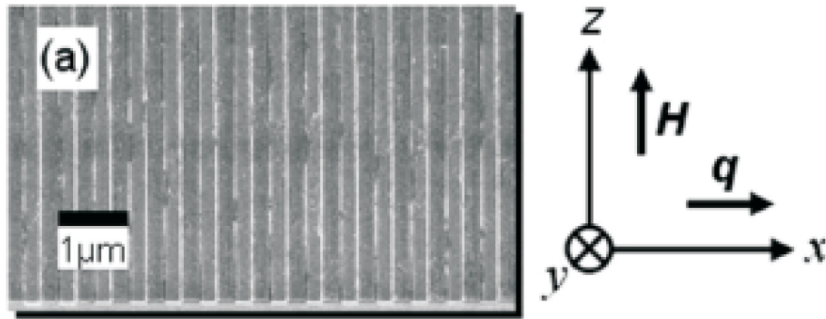
Magnonic Crystals



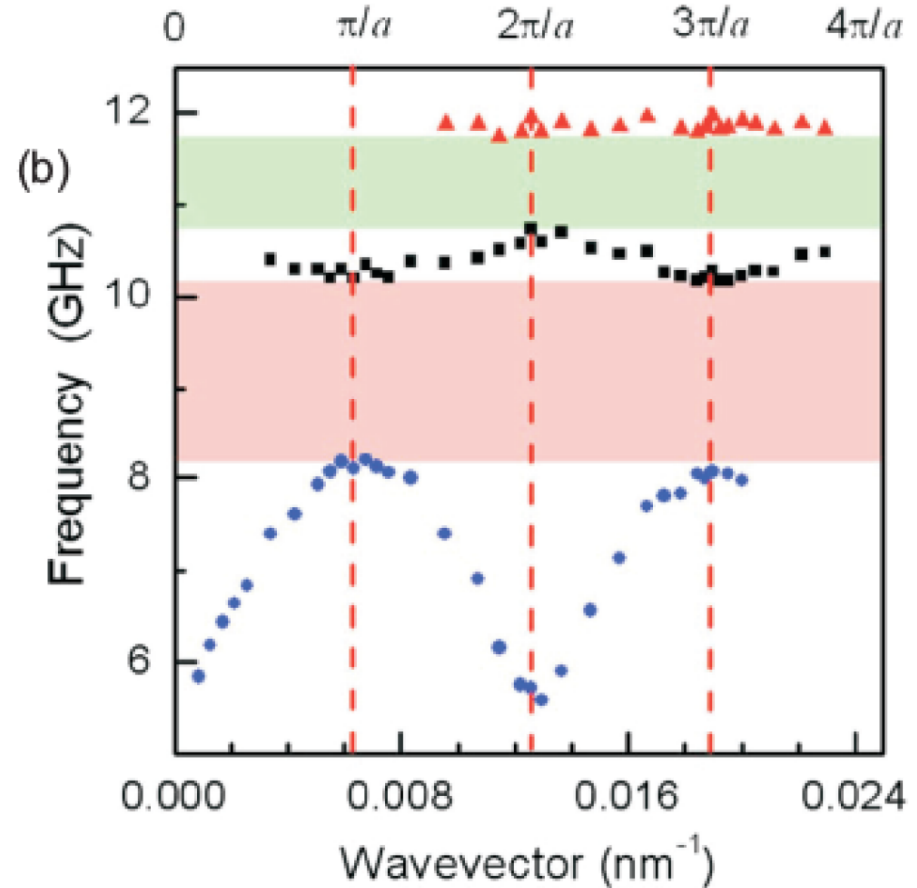
Magnonic Crystals



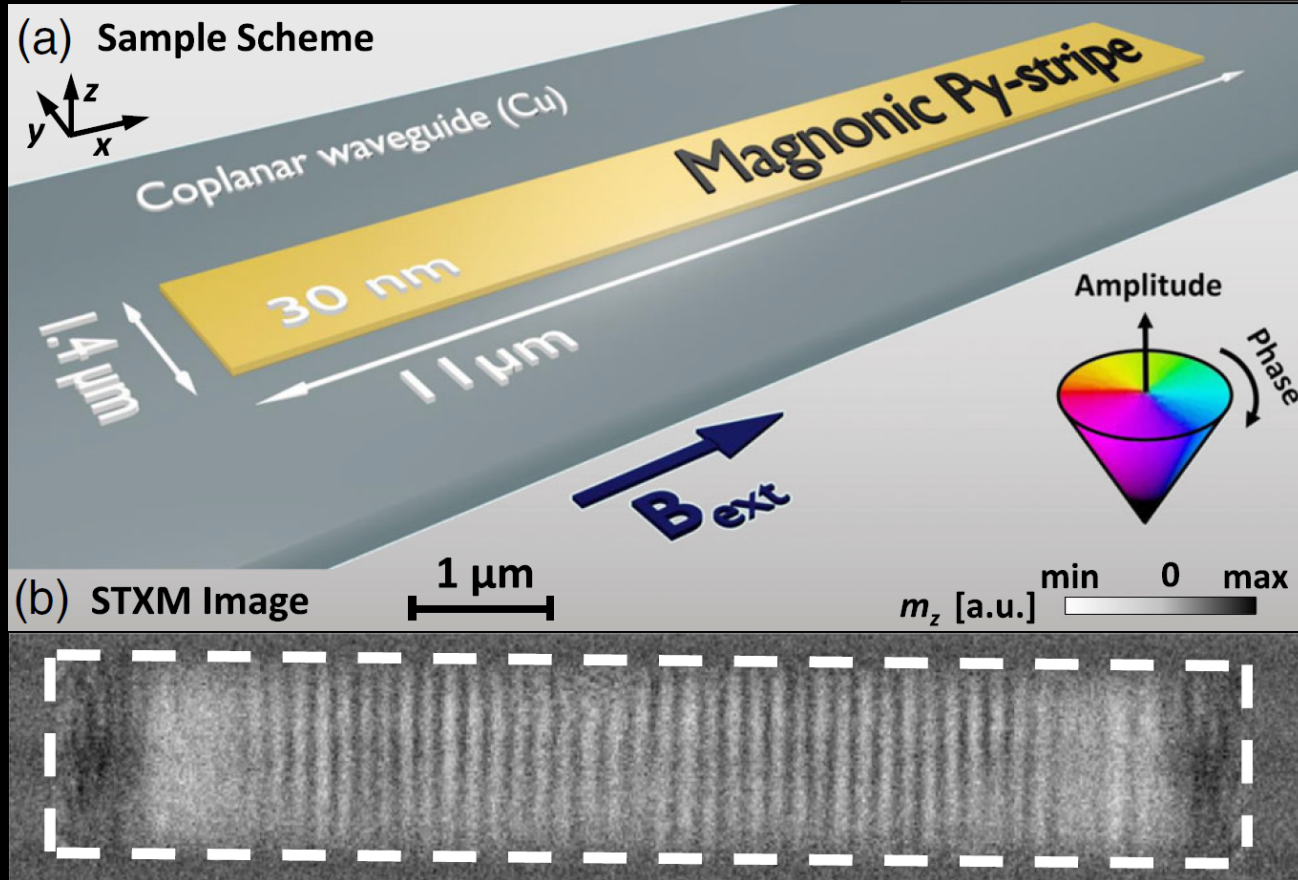
Magnonic Crystals



- Permalloy – Cobalt stripes

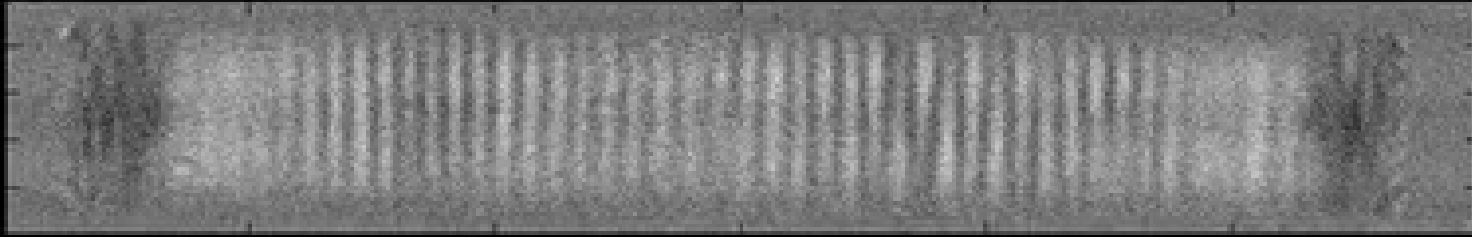


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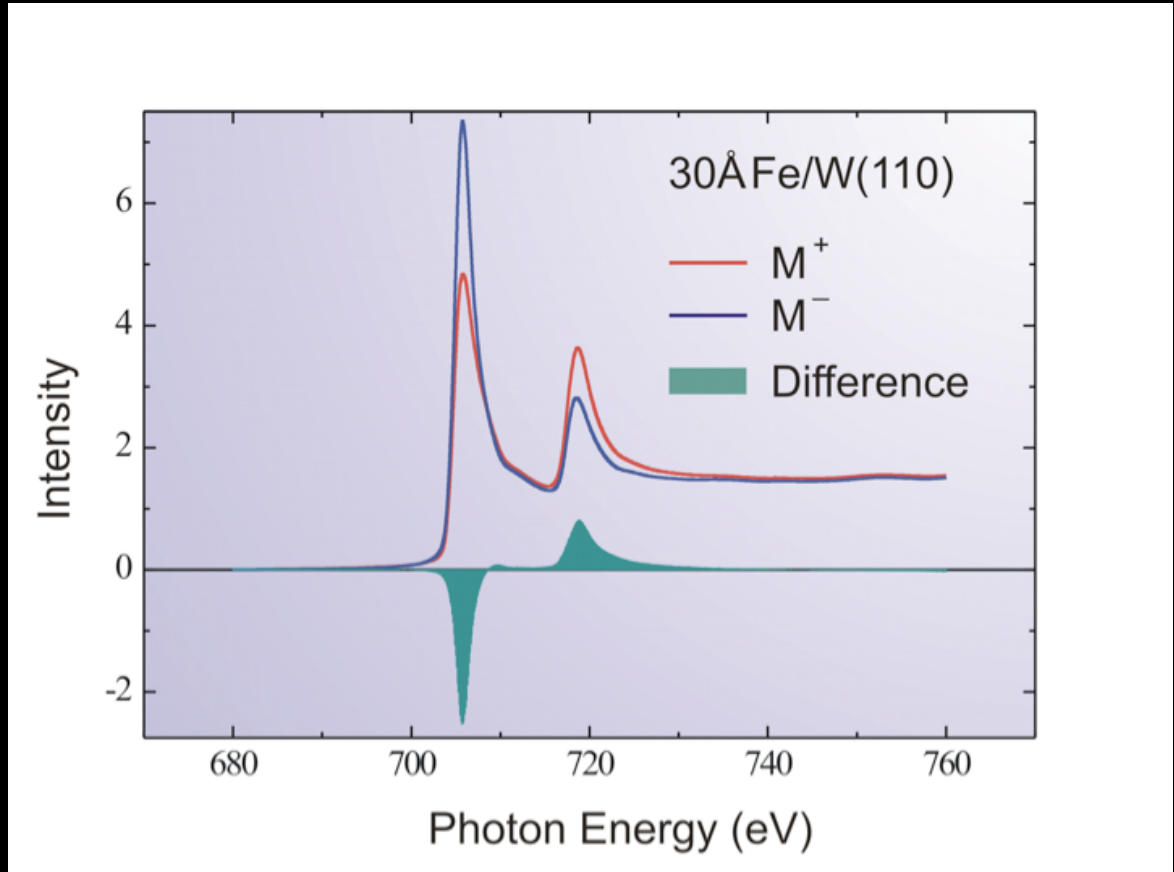
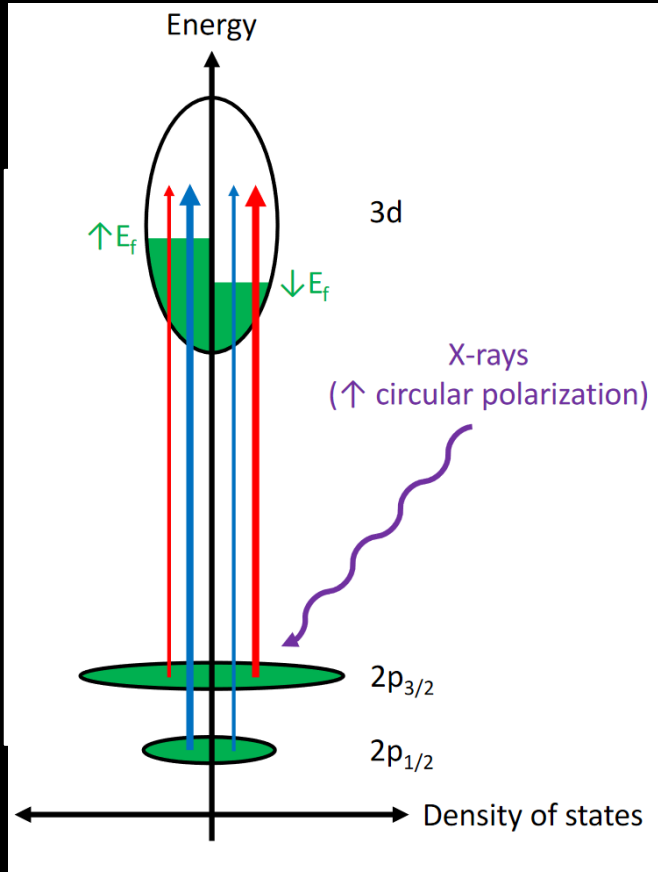


- Permalloy:
80% Ni
20% Fe
- $B_{\text{ext}} = 8\text{mT}$
- $f_{\text{rf}} = 4.2\text{GHz}$
- $\mu_0 h_{\text{rf}} = 450\text{ μT}$

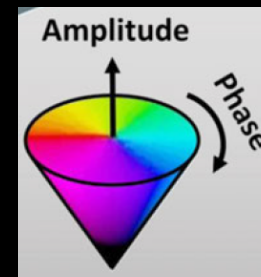
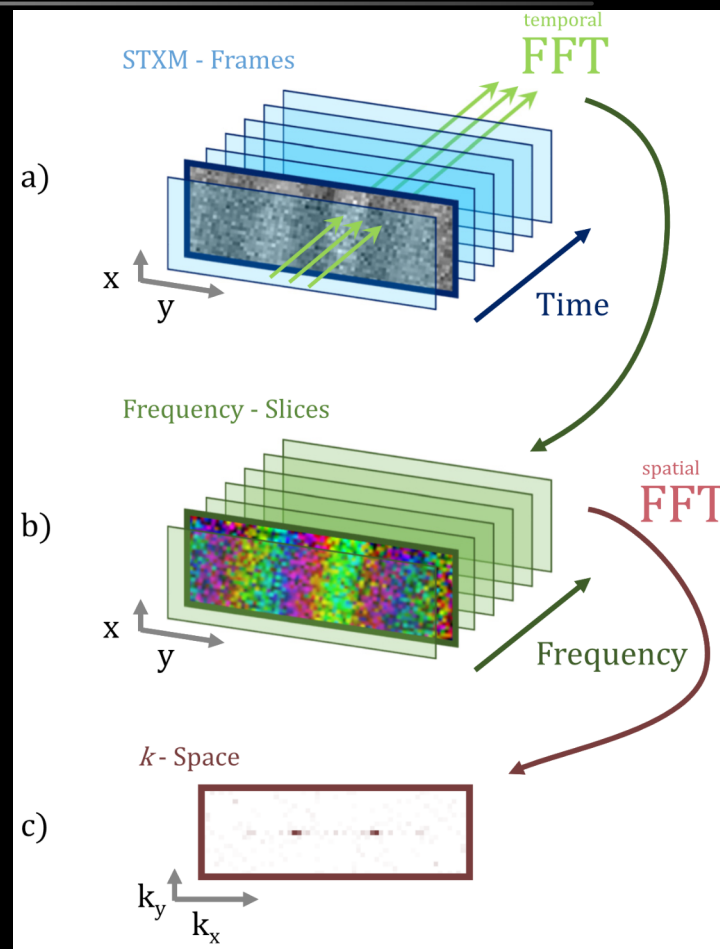
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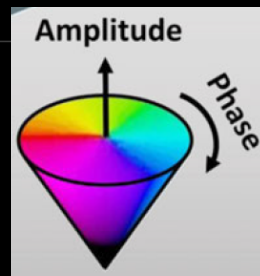
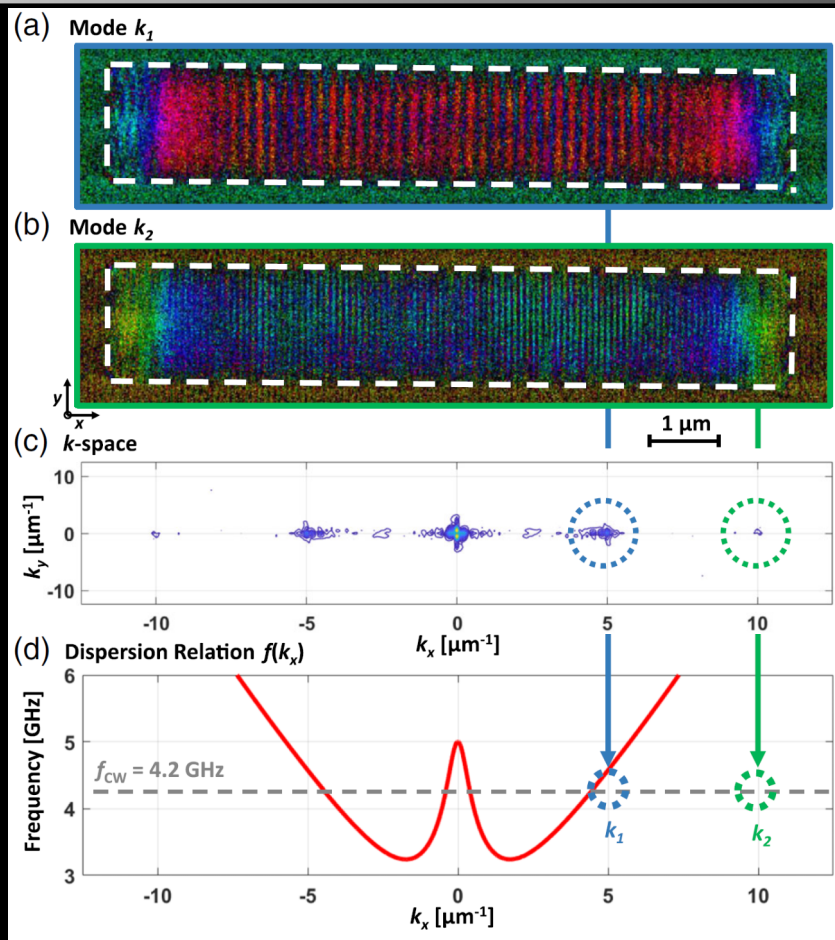
XMCD – X-Ray Magnetic Circular Dichroism



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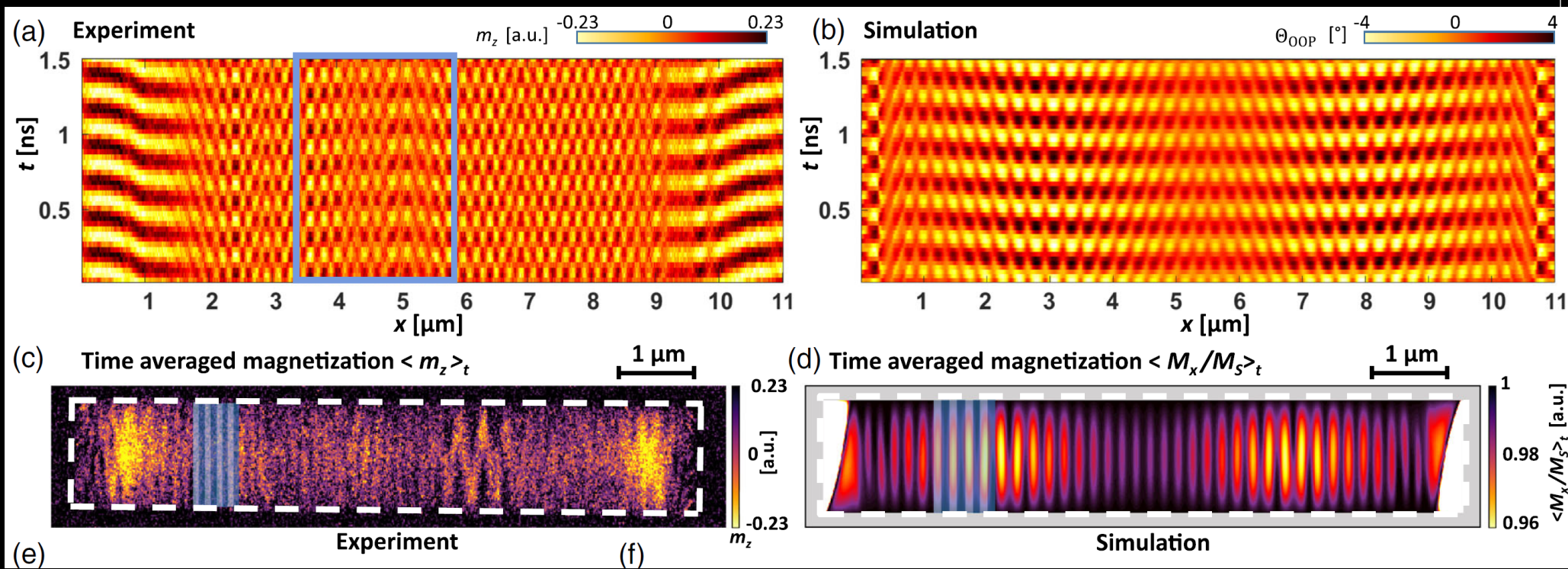


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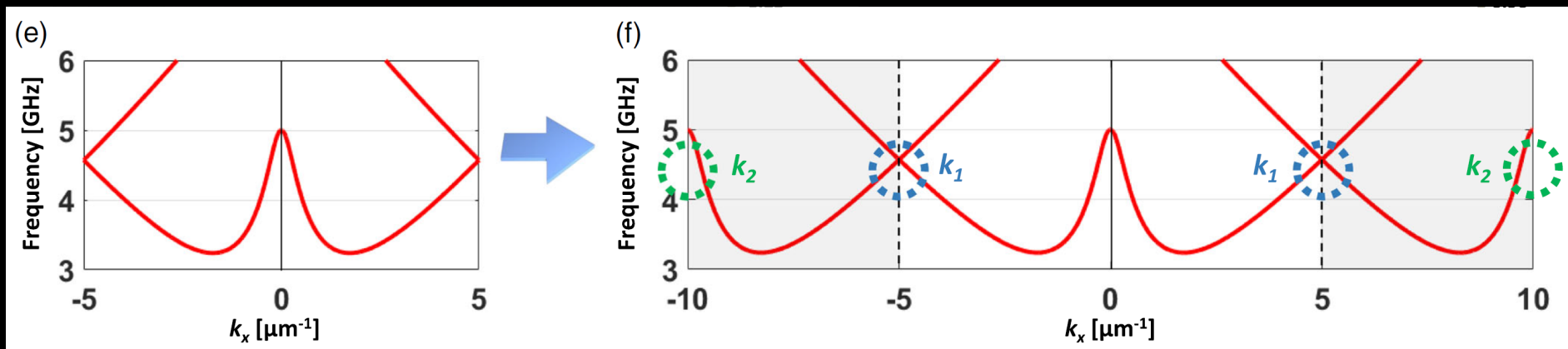
- k_1 described good by dispersion relation
- k_2 can not be described by dispersion relation

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- Periodic in Space and Time

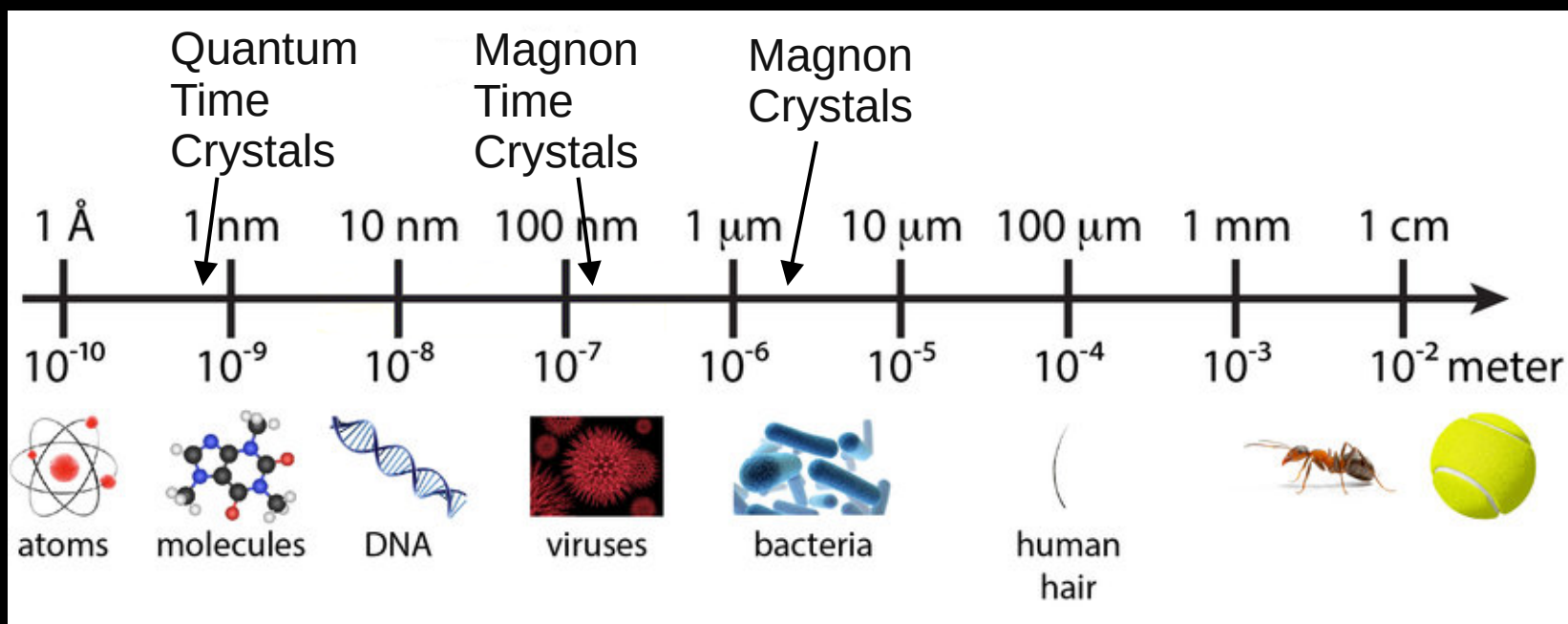
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- k_2 as a result of scattering on the periodic magnetization pattern at k_1

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Scale Comparison



Conclusion

- Magnonic Crystal on a homogenous Py-Strip
- Simulation with a classical ansatz leads to same Results as the Experiment
- Scattering of incident magnons on magnonic crystal potential
- Time crystal obtained at Room-Temperature in a classical large system

Thank you for your attention