2nd Transnational Round Table on Magnonics, High-Frequency Spintronics, and Ultrafast Magnetism

Ultrafast magnetic dynamics in antiferromagnets and altermagnets: nonlinearity, nonreciprocity, nondegeneracy

(in-depth report)

O. Gomonay[a]

a: Johannes Gutenberg University of Mainz, Germany

Although antiferromagnets have been the subject of intense study for nearly a century, they continue to present new surprises and generate significant interest among researchers. The recent identification of a novel class of magnetic materials, known as altermagnets—previously classified as antiferromagnets—has unveiled new possibilities and raised fundamental questions. In this talk, I will explore one of these questions: How does the altermagnetic spin splitting of electronic bands influence the magnetic dynamics of localized moments? What new physical phenomena can we expect, and how might these insights be applied to advance spintronic technologies?

In this talk, I will present recent findings from various research groups highlighting unexpected and nontrivial aspects of magnetic dynamics in altermagnets and antiferromagnets. These include phenomena such as altermagnon splitting [1], nonreciprocal surface waves [2], the spin diode effect in hematite, and light-induced nonlinear dynamics in antiferromagnets [3,4].

In my discussion, I will connect various dynamical effects to the symmetry of the local environment surrounding magnetic atoms. I will demonstrate how symmetry considerations can be used to predict the presence of efficient spin torques in both conducting (e.g., RuO_2) and insulating (e.g., hematite) altermagnets, as well as in antiferromagnets such as Mn_2Au.

I will also explore alternative spin torques that can be excited in insulating antiferromagnets, drawing on recent findings from thin films of NiO/Pt. In this context, the light-induced excitation of high-frequency magnon modes is driven by magnetoelastic effects. This mechanism, known as the thermo-magneto-mechanical effect, involves inhomogeneous thermal expansion at the interface between the heavy metal and the insulating antiferromagnet, leading to the generation of shock acoustic waves and rapid magnetic dynamics mediated by the magnetoelastic interaction.

Finally, I will provide a brief overview comparing magnetic dynamics and transport in ferromagnets, antiferromagnets, and altermagnets, addressing the key question: How can spintronics benefit from each of these materials?

2nd Transnational Round Table on Magnonics, High-Frequency Spintronics, and Ultrafast Magnetism

[1] O. Gomonay, et al, *Structure, control, and dynamics of altermagnetic textures* npj Spintronics **2**, 35 (2024)
[2] A. Kanj, et al, *Evidence of non-degenerated, non-reciprocal and ultra-fast spin-waves in the canted antiferromagnet α -Fe_2O_3* Sci. Adv. 9, eadh1601 (2023)
[3] E. Rongione, et al, *Emission of coherent THz magnons in an antiferromagnetic insulator triggered by ultrafast spin–phonon interactions*. Nature Comm. **14**, 1818 (2023)

[4] Y. Behovits, et al, *Terahertz Néel spin-orbit torques drive nonlinear magnon dynamics in antiferromagnetic Mn_2Au* Nature Comm. 14**,** 1 (2023)