




Workshop „Spin Caloritronics III“ Leiden, May 2011

Magnon Spintronics / Spincaloritronics


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Electronics – Spintronics – Magnonics



Electronics	Spintronics	
Carrier of information: charge of electron	Carrier of information: spin of electron	


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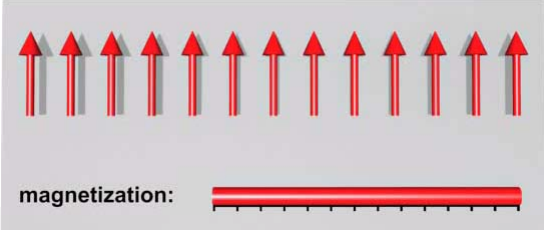

Electronics – Spintronics – Magnonics


Electronics	Spintronics	Magnonics
Carrier of information: charge of electron	Carrier of information: spin of electron	Carrier of information: magnon

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Ferromagnetic spin chain: magnon




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“Magnon spintronics” team

Kaiserslautern Team




V. Vasyuchka



A. Chumak



A. Serga



T. Neumann



P. Pirro


External Collaborators

M. Kostylev (University of Western Australia, Crawley, Western Australia, Australia)

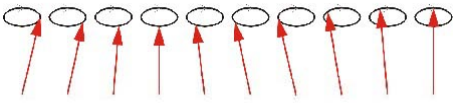
A. Karenowska, J. Gregg (Department of Physics, University of Oxford, UK)

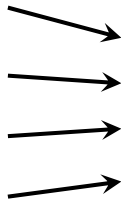
V. Tiberkevich, A. Slavin (Oakland University, Rochester, Michigan, USA)

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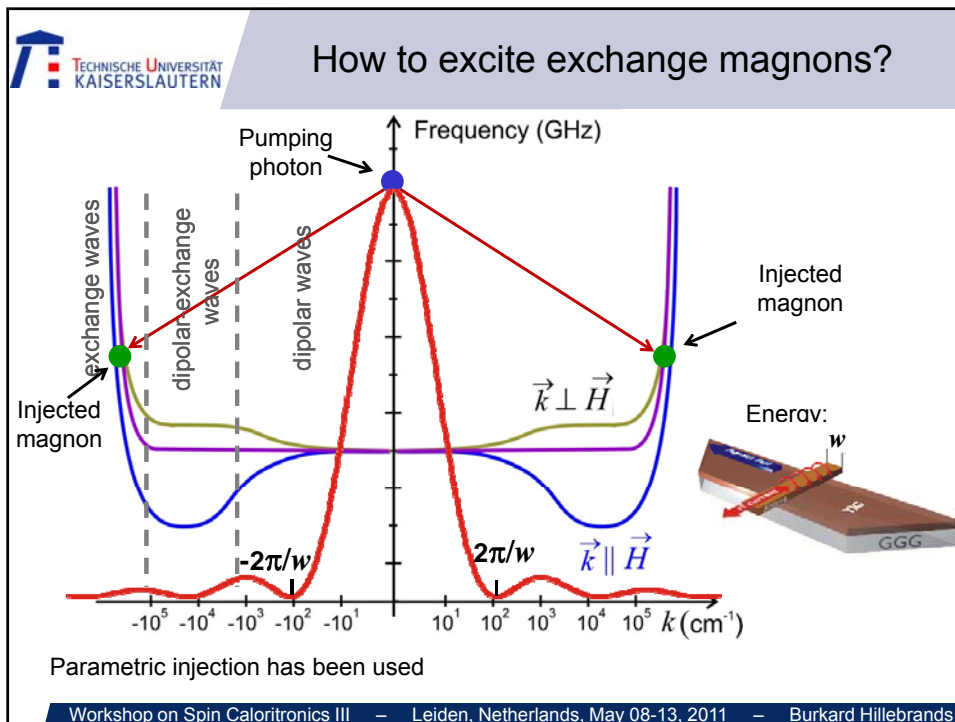
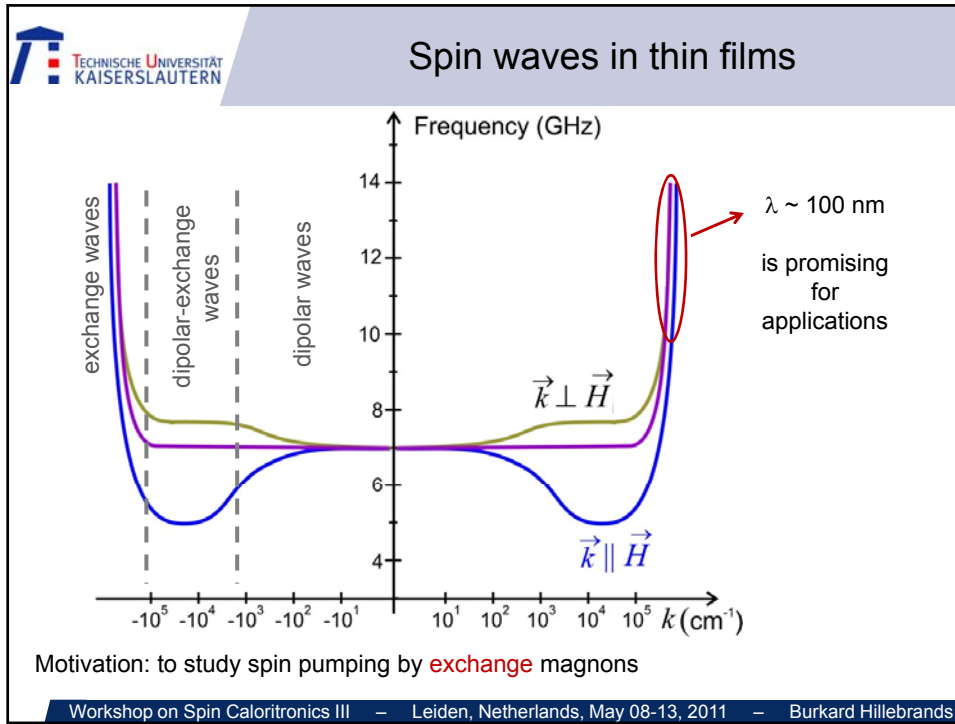
Spin-wave characteristics




<p>Wavelength: from nm to cm</p> <p>Frequency: GHz band</p> <p>Velocity: ~1 cm/μs</p> <p>Lifetime: up to 700 ns</p>		<p>signal processing & transfer in GHz range on nano-scale</p>
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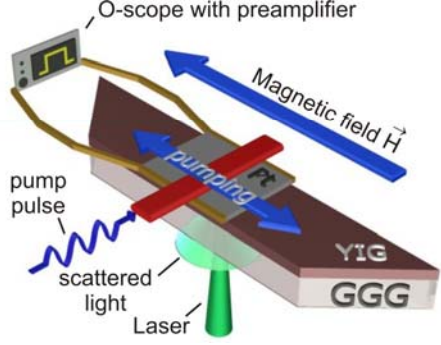
Magnon-Spintronics

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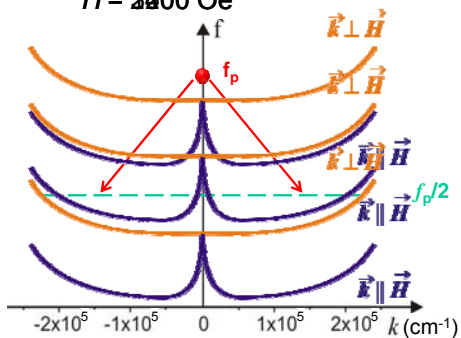


Experimental setup



O-scope with preamplifier
 Magnetic field \vec{H}
 pump pulse
 scattered light
 Laser
 Pt
 YIG
 GGG

$H = 3000 \text{ Oe}$




$\vec{k} \perp \vec{H}$
 $\vec{k} \parallel \vec{H}$
 f_p
 $f_p/2$
 k (cm⁻¹)

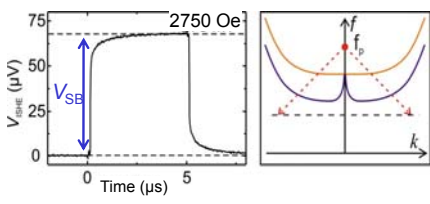
- sample: YIG 2 μm / Pt 10 nm
- magnon detection: BLS spectroscopy
- pump frequency $f_p = 14 \text{ GHz}$

wavevector up to $5.6 \cdot 10^5 \text{ cm}^{-1}$ ($H \approx 0$)

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Longitudinal Spin-Seebeck effect



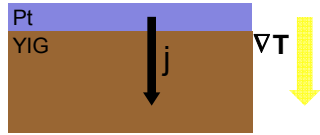
V_{SHE} (μV)
 Time (μs)
 2750 Oe
 V_{SB}

$H = 2750 \text{ Oe}$:

- No magnon injection!
- V_{ISHE} -signal (V_{SB}) still observable

Why?

- eddy currents: heating of the sample
- $T_{\text{Platinum}} > T_{\text{YIG}}$
- thermal fluctuations
 - magnons in YIG
 - free electrons in Pt
- spin injection due to thermal fluctuations

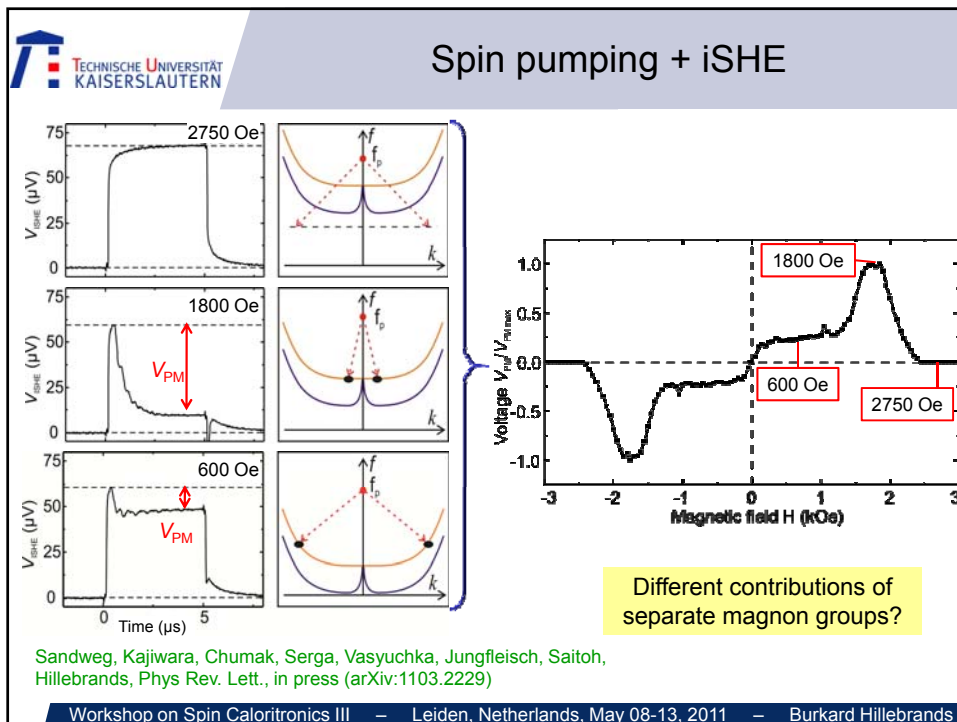
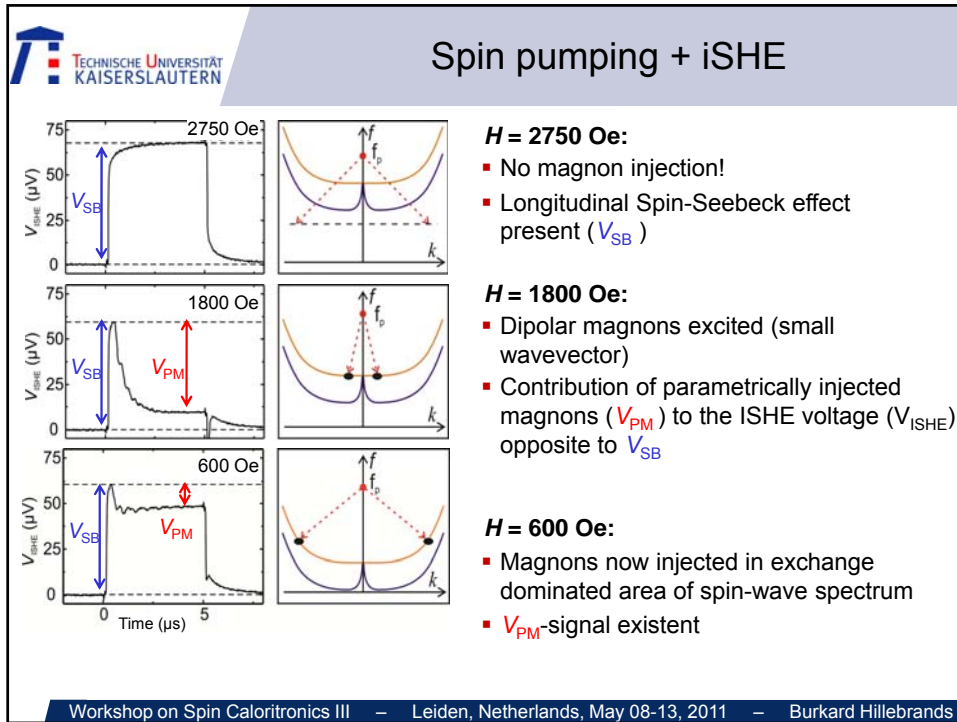


Pt
 YIG
 \vec{j}
 ∇T

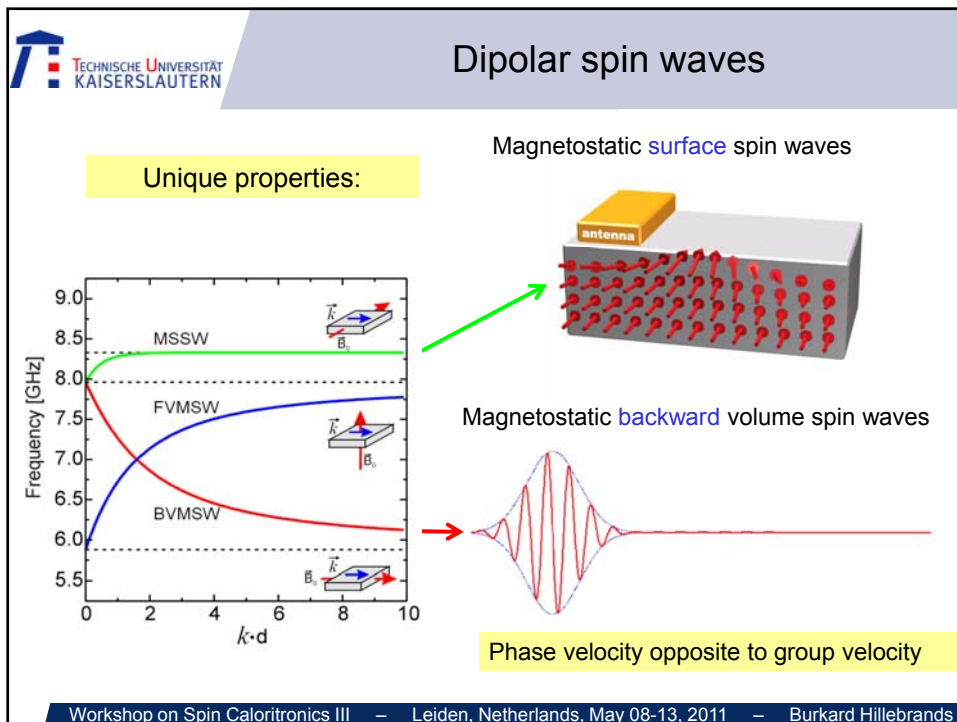
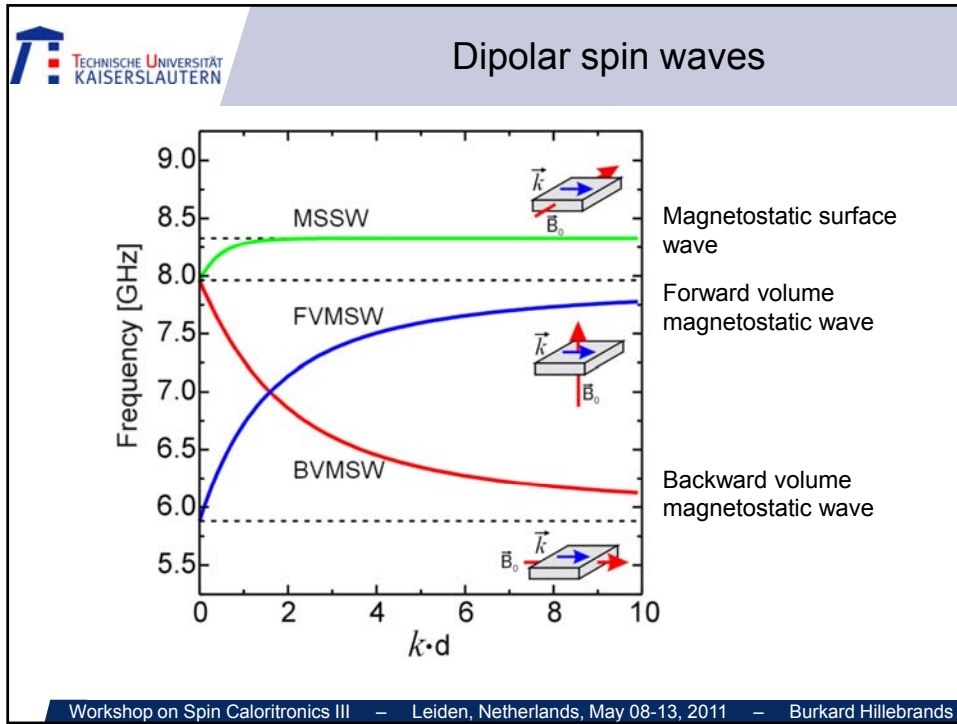
Uchida et al., Appl. Phys. Lett. 97, 172505 (2010)


Longitudinal Spin-Seebeck effect

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Sandweg, Kajiwara, Chumak, Serga, Vasyuchka, Jungfleisch, Saitoh, Hillebrands, Phys Rev. Lett., in press (arXiv:1103.2229)

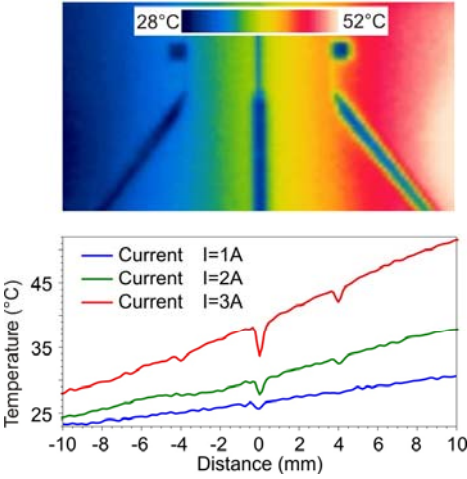





Experimental setup



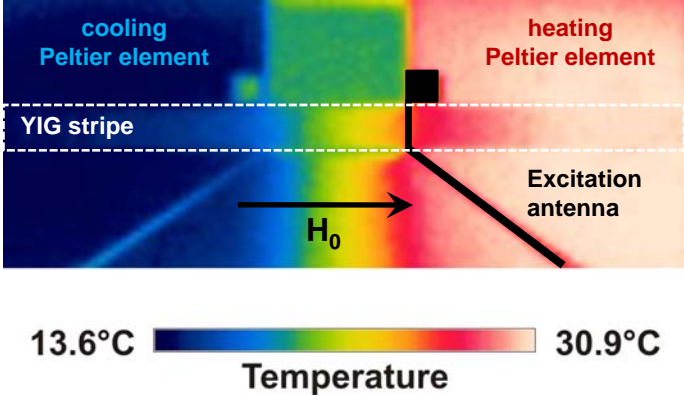
- Al₂O₃ substrate
- 2 Peltier elements in series, one for heating, one for cooling
- Yttrium Iron Garnet (YIG) stripe: thickness = 6.7 μm, width = 1.2 mm
- BLS forward scattering
- phase-resolved measurements using the electro-optic modulator



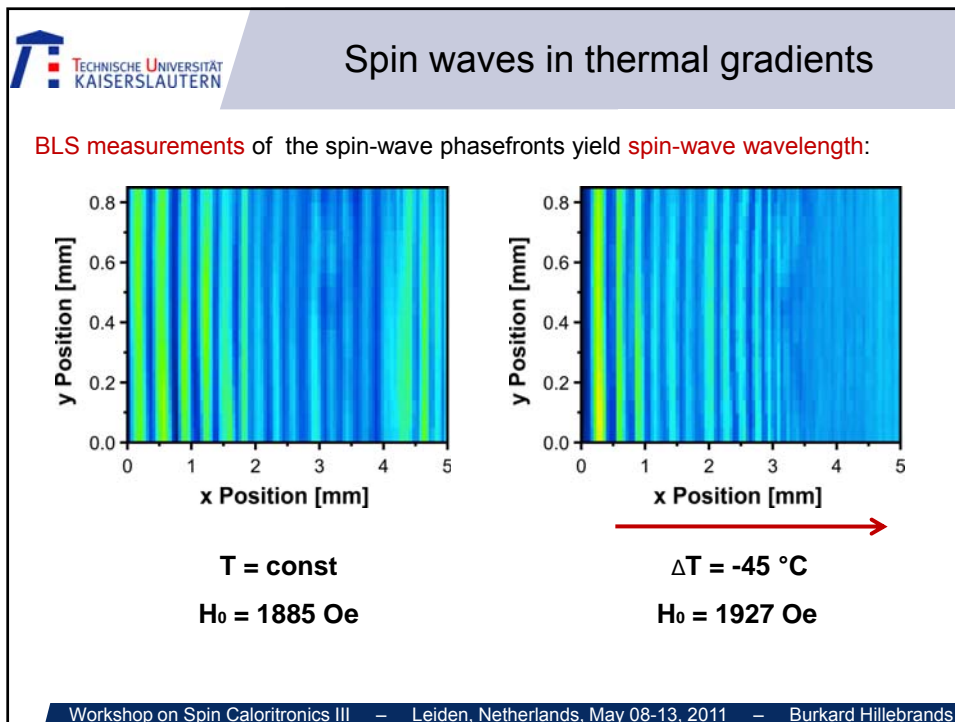
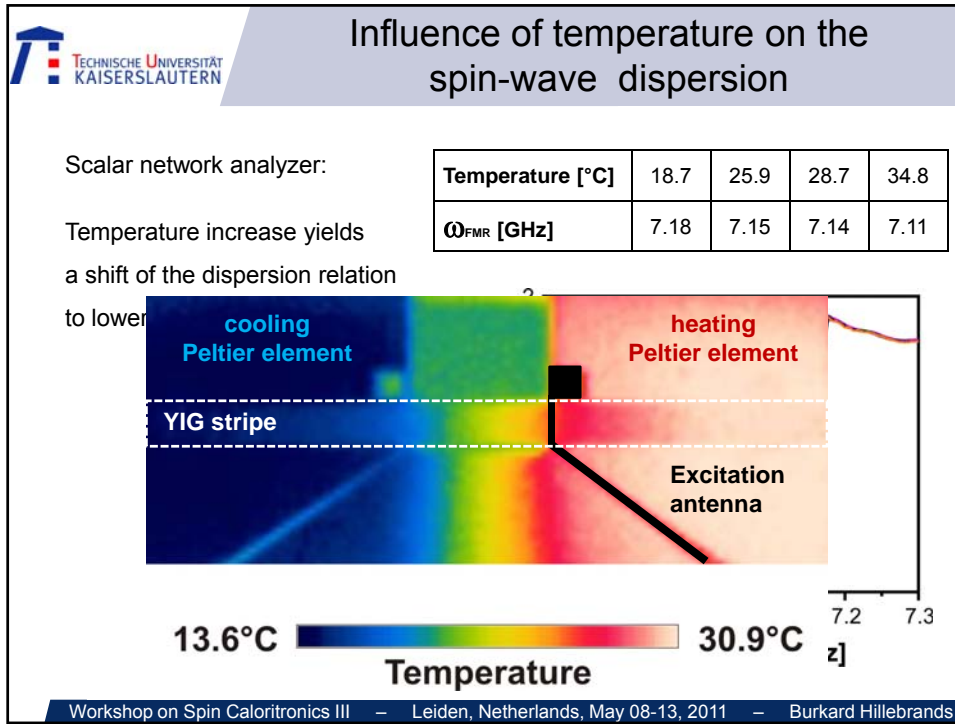
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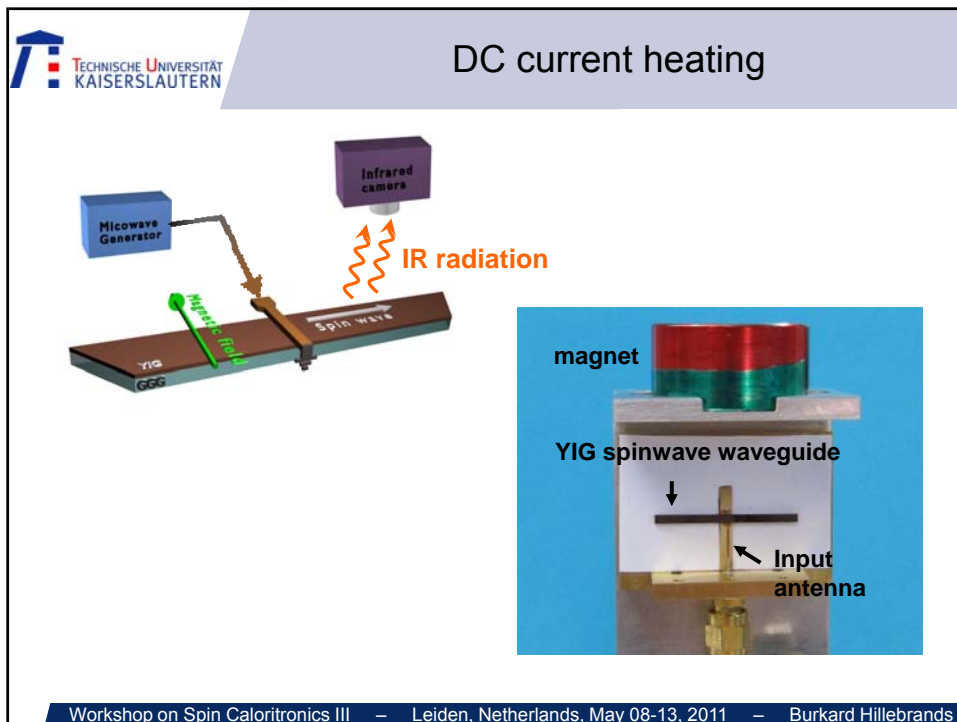
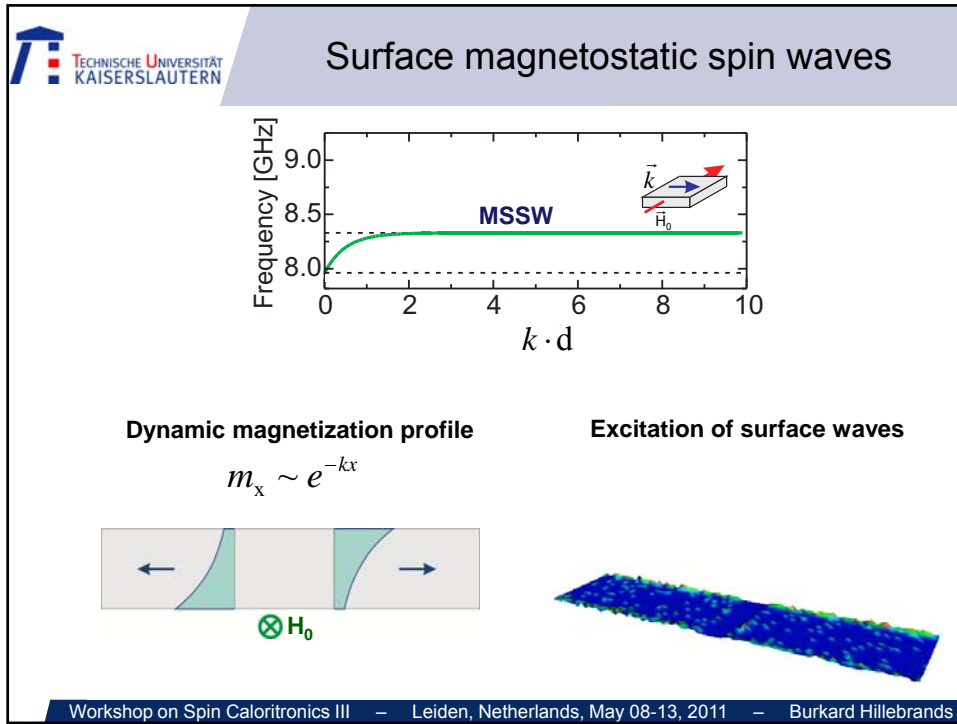


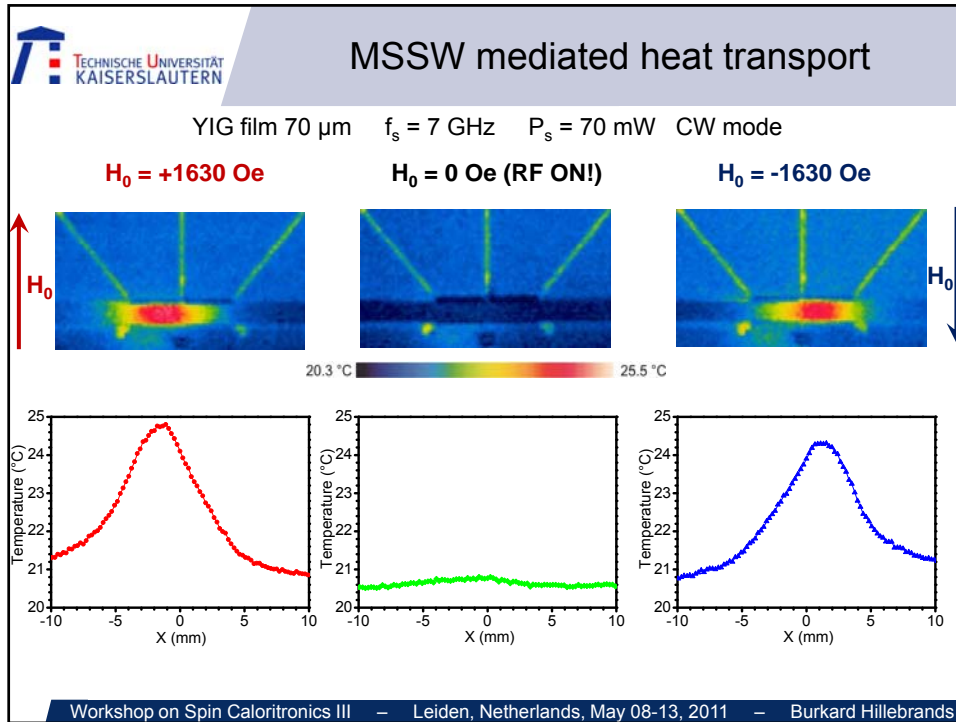
Experimental setup



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Conclusions

- Demonstration of spin pumping by parametrically excited exchange magnons
- Detection of influence of longitudinal Spin-Seebeck effect in magnetic insulator – nonmagnetic metal bilayers
- First observation of heat transport by magnons using infrared thermography technique
- Spin waves in a temperature gradient have been investigated
- Realization and application of dynamic magnonic crystals

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