RQC Russian Quantum Center

Prof. Matti Krusius vuosipäivä

Espoo, Finland, 4-5 November 2022

Yu. M. Bunkov

Topological Q-bit based on magnon Bose-Einstein condensation.

Laboratory of Quantum Magnonics, Russian Quantum Center, Skolkovo, B. Bulvar 30, 121205, Russia

The spectra of magnons at different conditions have a fundamentally different form.
They can be characterized by an attractive or repulsive interaction, positive, zero or negative mass.

1. Does our spatially homogeneous coherent state of magnons go beyond the Landau-Lifshitz approximation?
2. Can magnons with mass anisotropy be considered a Bose condensate?
3. The traveling spin waves with k = 10^5 1/cm.
Can it be considered as Bose condensate or analogue of photon modes in a resonator?

Supported by Russian Science Foundation, grant 22-12-00322

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A few questions about magnon Bose condensation.

Laboratory of Quantum Magnonics, Russian Quantum Center, Skolkovo, B. Bulvar 30, 121205, Russia

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They can be characterized by an attractive or repulsive interaction, positive, zero or negative mass.

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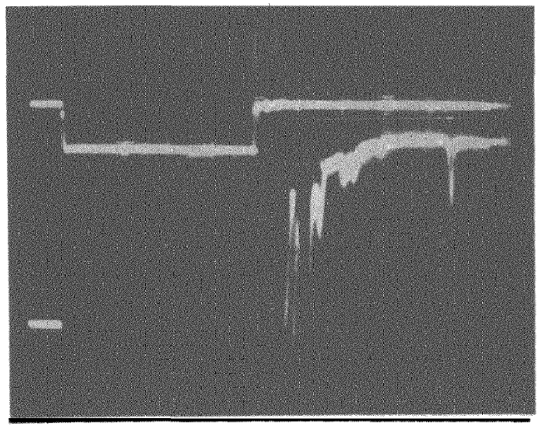
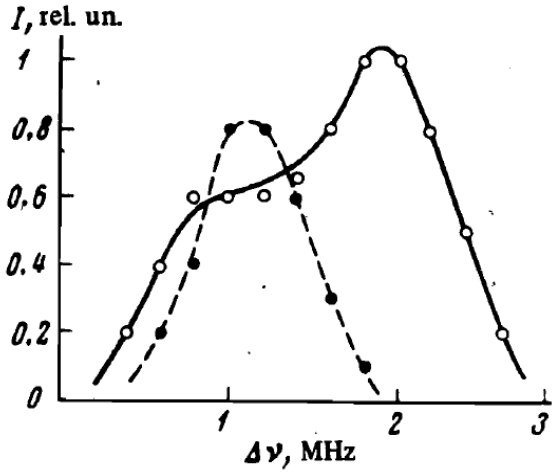
Prehistory 1977 Soviet –Finland collaboration P. Kapitza-W. Hovy

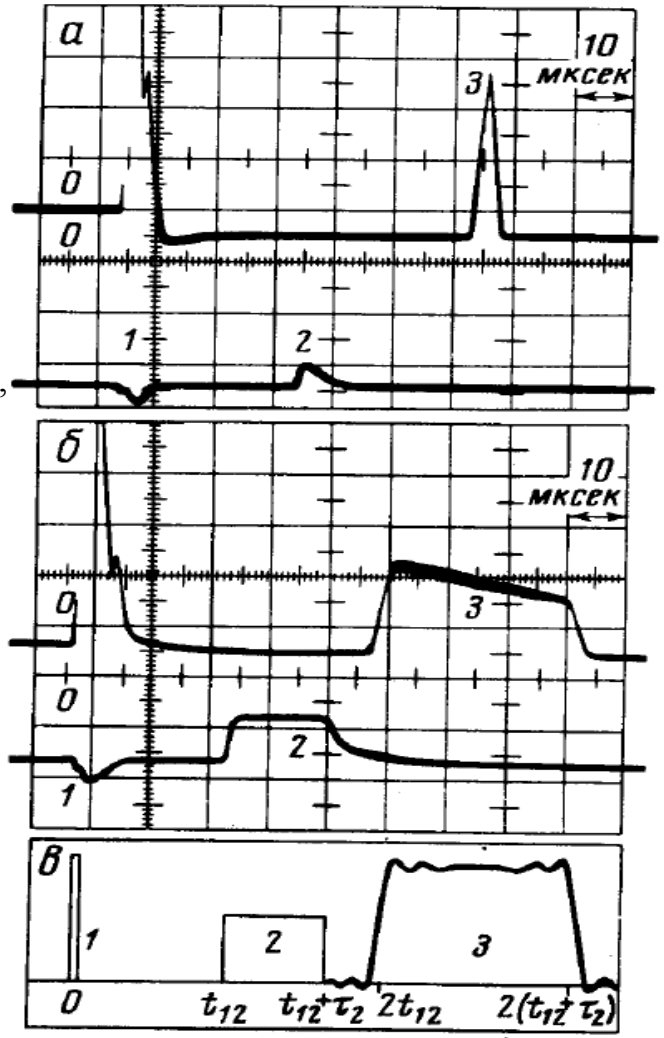


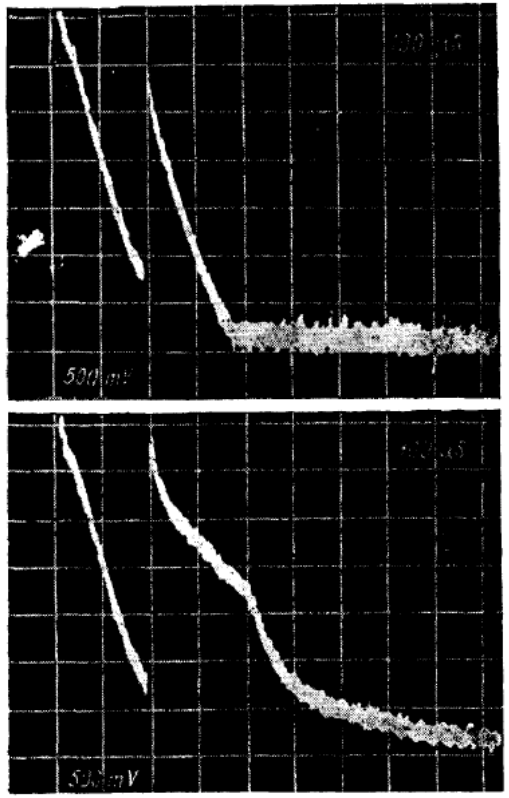
Yu.M.Bunkov, B.S.Dumesh, M.I.Kurkin."Single Pulse Nuclear Spin Echo with Pulling". JETPh Letters v.19, p.132 (1974).

Yu.M.Bunkov, "Parametric Nuclear Spin Echo", JETPh Letters v.23, p.244 (1976).



Yu.M.Bunkov, B.S.Dumesh, "Dynamic Effect in Pulsed NMR with a Large Dynamical Frequency Shift"' Sov. Phys. JETPh v.41, p.576 (1975);





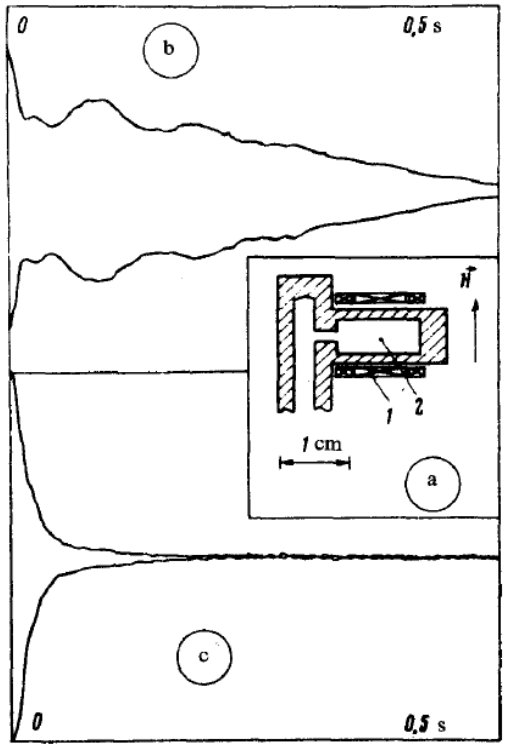
Yu.M.Bunkov, M.Punkkinen, E.E.Ylinen, "Fe57 NMR Frequency Pulling Investigations at FeBO3", Sov.Phys.JETPh v.47, p.615 (1978).

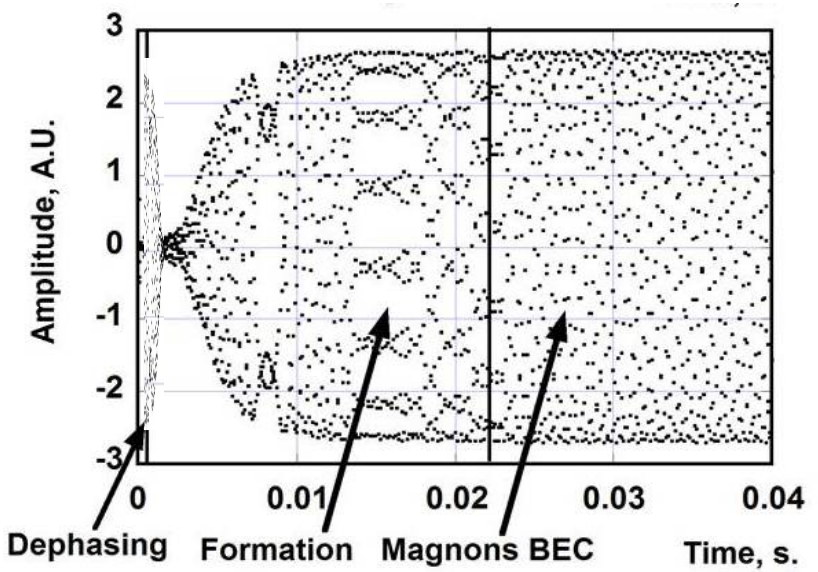
Magnon BEC and magnon superfluidity in antiferromagnetic ^{3}He-B

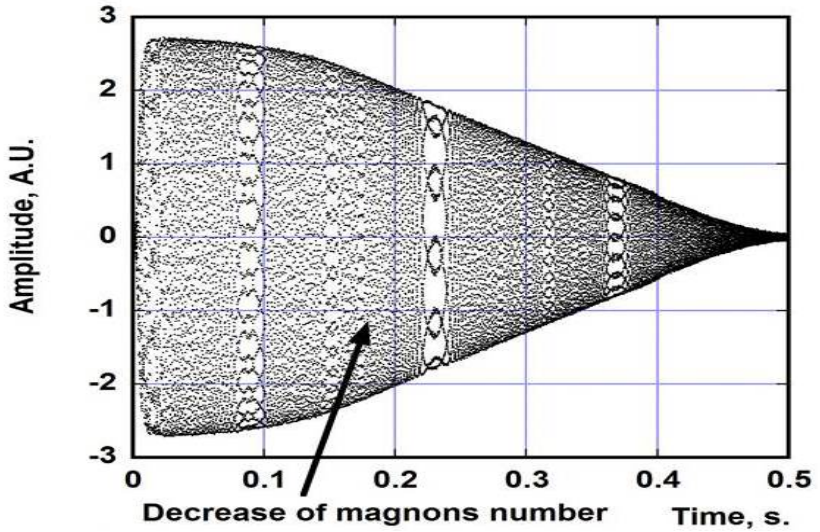
Long-lived induction signal in superfluid ^{3}He-*B*

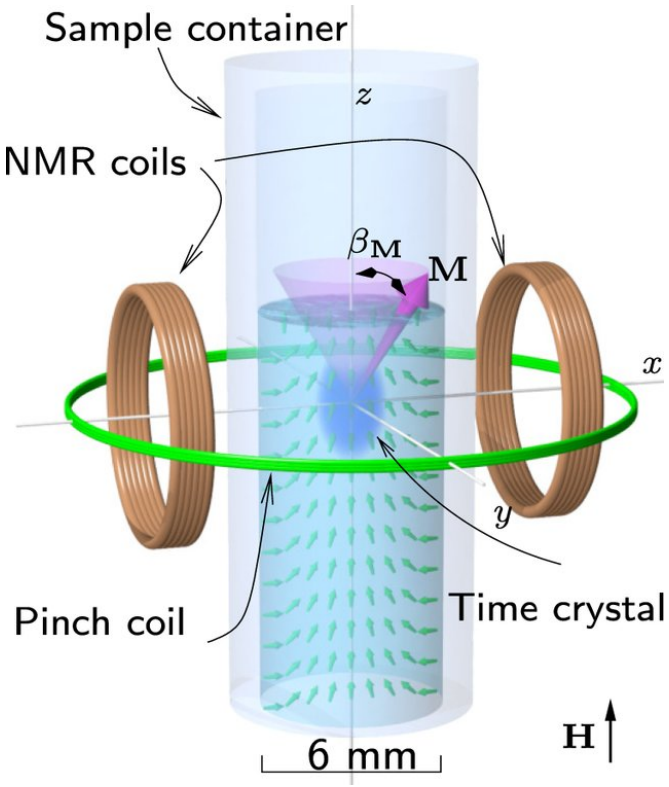
A. S. Borovik-Romanov, Yu. M. Bun'kov, V. V. Dmitriev, and Yu. M. Mukharskiĭ
Institute of Physical Problems, Academy of Sciences of the USSR

(Submitted 16 August 1984)
Pis'ma Zh. Eksp. Teor. Fiz. **40**, No. 6, 256–259 (25 September 1984)





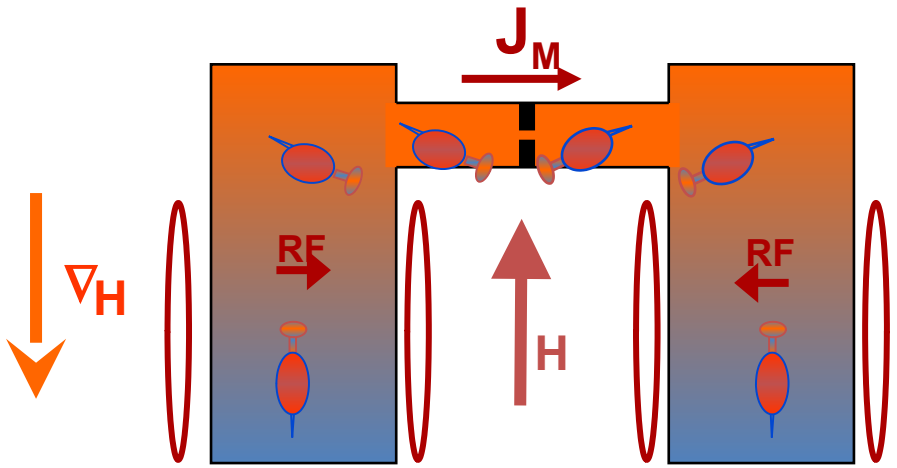


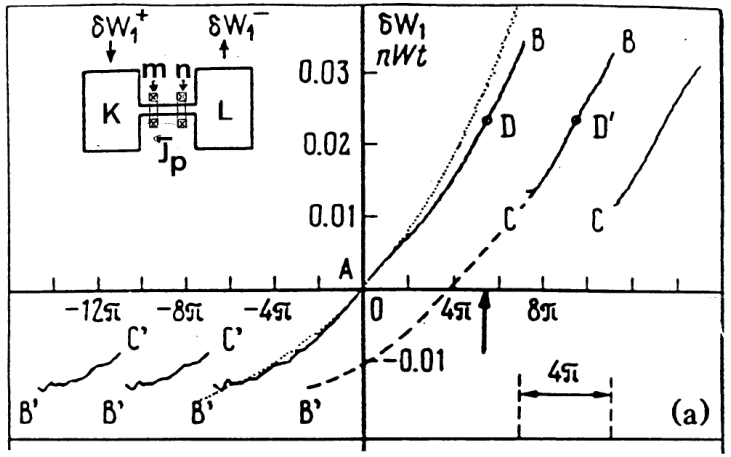


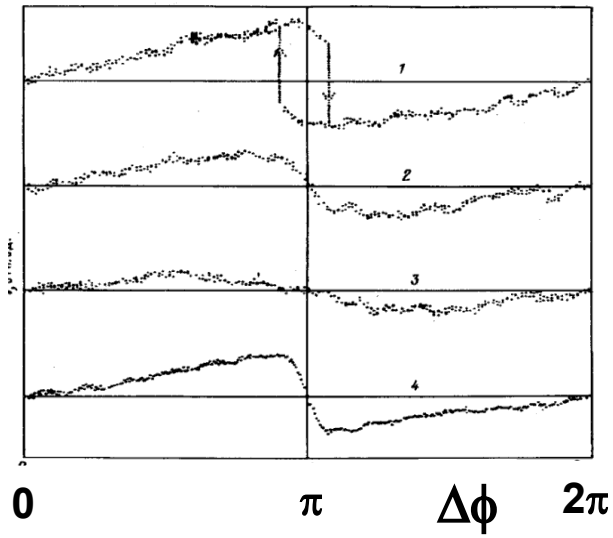
- June 2022

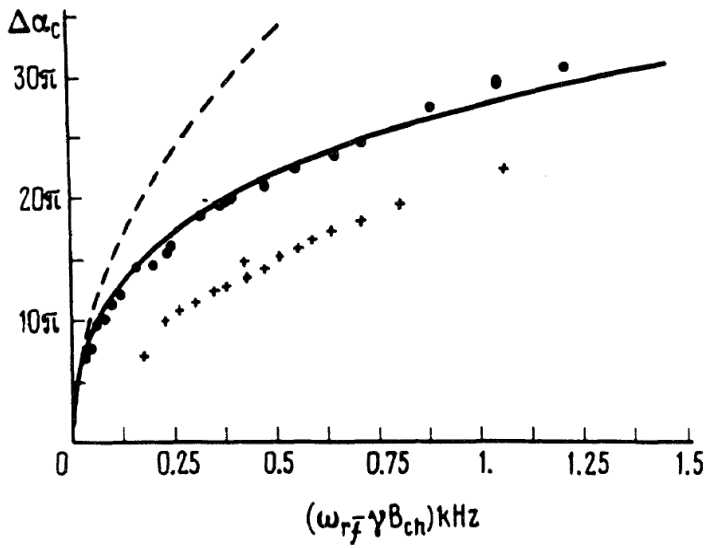
Critical current and Josephson effect

$$J_{M_z}^{\perp} = -(\chi/\gamma)[(1-\cos\beta)^2 c_{\parallel}^2 + (1-\cos^2\beta)c_{\perp}^2]\nabla\alpha$$









$\omega = f(N)$ $\omega - \gamma H$

Frequency shift due to magnon-magnon interaction

$$\xi_0 = 1.088 c_{\parallel}/\sqrt{\omega(\omega - \gamma H)}$$

VOLUME 62, NUMBER 14 PHYSICAL REVIEW LETTERS 3 APRIL 1989

Investigation of Spin Supercurrents in ^{3}He-*B*

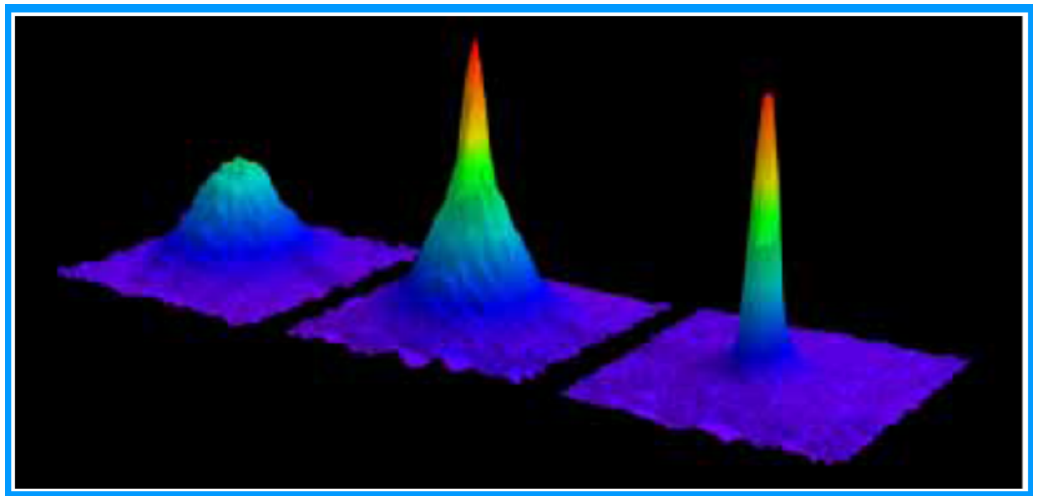
A. S. Borovik-Romanov, Yu. M. Bunkov, V. V. Dmitriev, Yu. M. Mukharskiy, and D. A. Sergatskov
Institute for Physical Problems, Kosygin St. 2, 117334 Moscow, U.S.S.R.
(Received 21 March 1988; revised manuscript received 16 November 1988)

Magnon BEC at room temperature

Atomic BEC

$$T_{BEC} \simeq 3.31 \frac{\hbar^2}{k_B m} (N_C)^{2/3},$$

Achieved by lowering the temperature below critical at a fixed particle density



Magnon Bose condensation

$$\hat{\mathcal{N}} = \hat{a}_0^\dagger \hat{a}_0 = \frac{\mathcal{S} - \hat{\mathcal{S}}_z}{\hbar} \qquad \varepsilon_k = \varepsilon_0 + \varepsilon_{ex}(ak)^2.$$

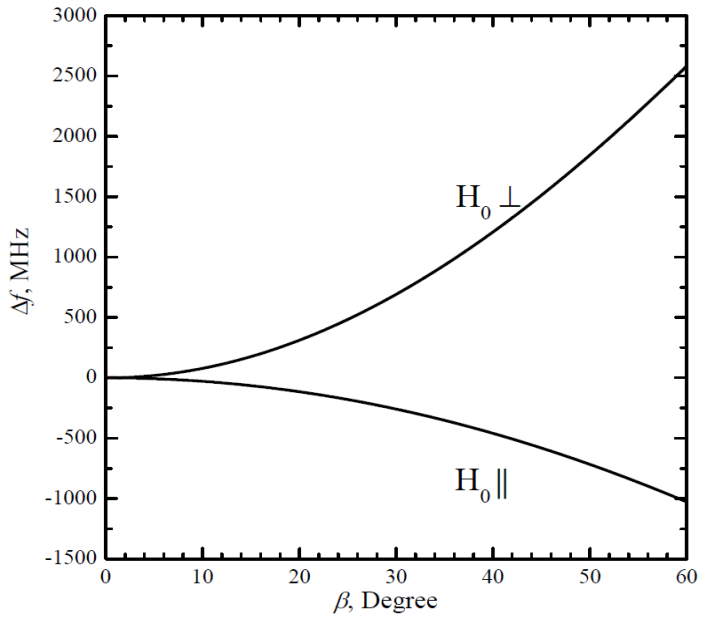
$$N_C \simeq \frac{k_B T_m}{4\pi a^3} \frac{\varepsilon_0^{1/2}}{\varepsilon_{ex}^{3/2}},$$

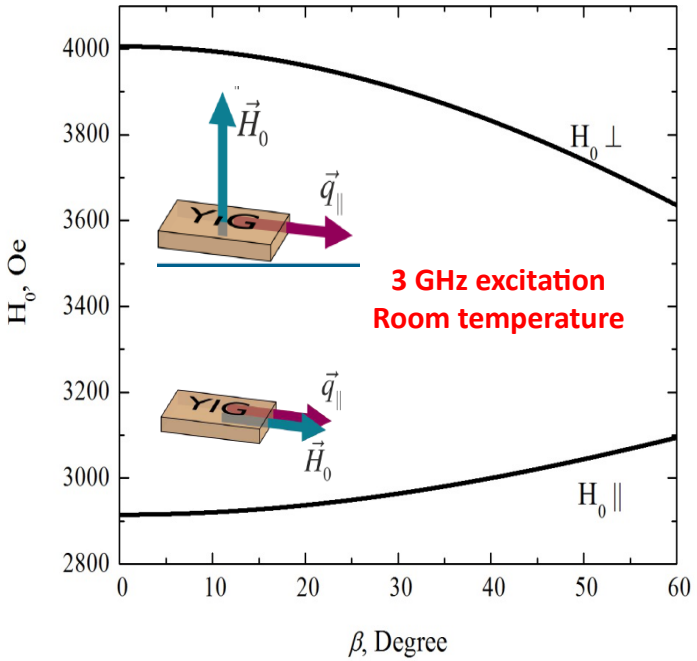
N_c corresponds to a 2.5^0 magnetization deflection in YIG film

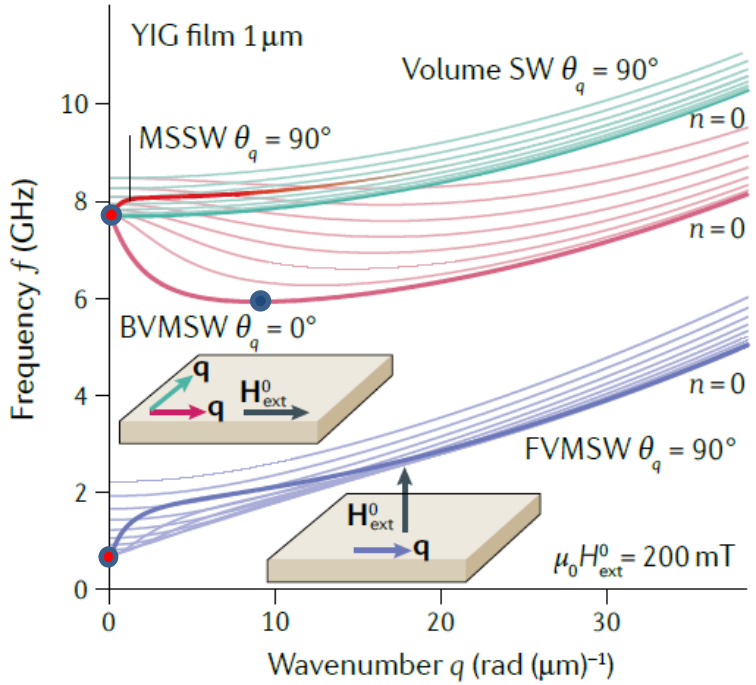
Yu. M. Bunkov, V. L. Safonov (JMMM) 452, 30 (2018)

$$\Psi = \sqrt{\frac{2S}{\hbar}} \sin\frac{\beta}{2} e^{i(\alpha+\omega t)}$$

YIG film, magnon excitation







$$T_{BEC} \simeq 3.31 \frac{\hbar^2}{k_B m} (N_C)^{2/3}, \qquad \hat{\mathcal{N}} = \hat{a}_0^\dagger \hat{a}_0 = \frac{\mathcal{S} - \hat{\mathcal{S}}_z}{\hbar} \qquad \varepsilon_k = \varepsilon_0 + \varepsilon_{ex}(ak)^2. \qquad N_C \simeq \frac{k_B T_m}{4\pi a^3} \frac{\varepsilon_0^{1/2}}{\varepsilon_{ex}^{3/2}},$$

Yu. M. Bunkov, V. L. Safonov (JMMM) 452, 30 (2018)

Anderson, P. W. & Suhl, H.
Instability in the motion of ferromagnets at high microwave power levels. *Phys. Rev.* **100**, 1788 (1955).

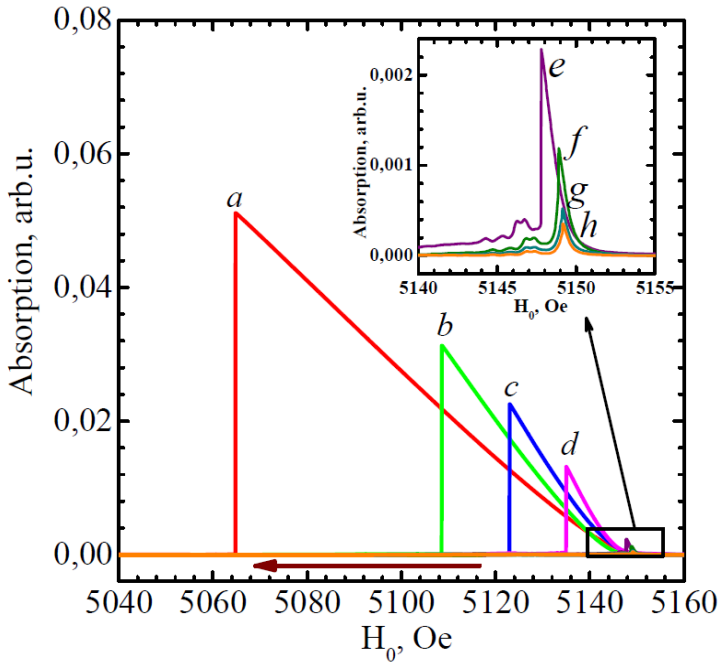
scientific reports 11, 7673 (2021).

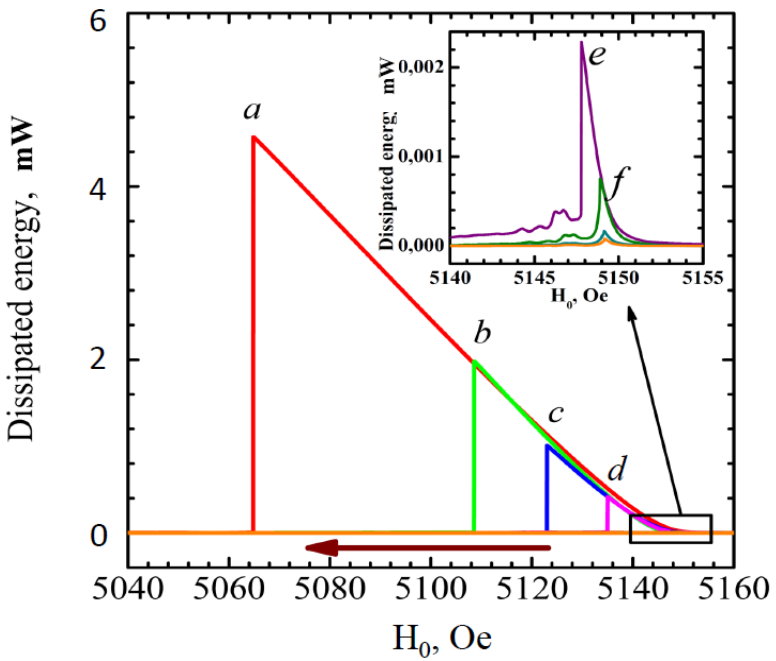
Check for updates

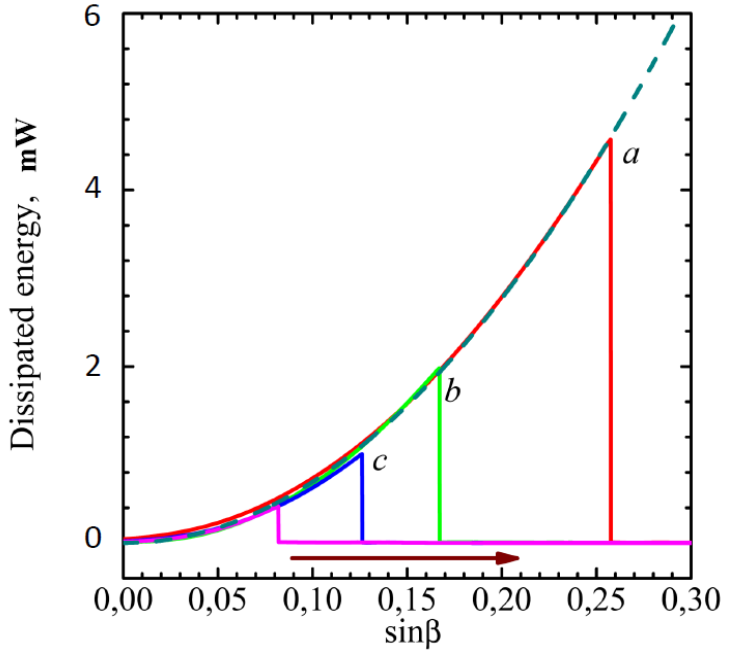
OPEN

Quantum paradigm of the foldover magnetic resonance

Yu. M. Bunkov[1✉], A. N. Kuzmichev[1], T. R. Safin[2], P. M. Vetoshko[1], V. I. Belotelov[1,3] & M. S. Tagirov[2]





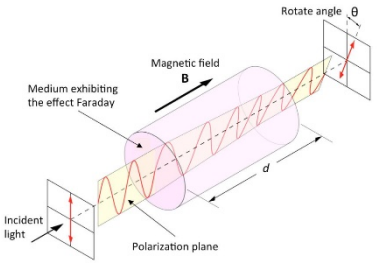


Optical set up

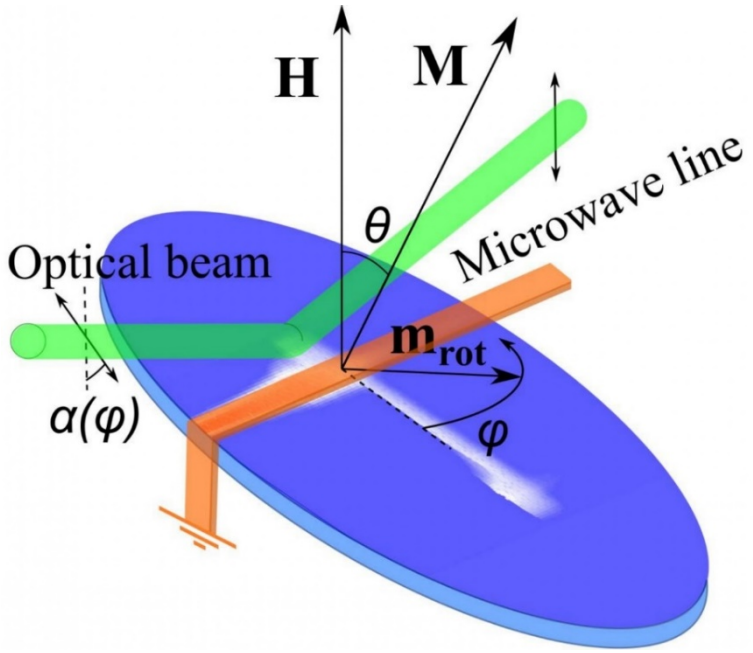
Research Article Vol. 30, No. 2 / 17 Jan 2022 / Optics Express 1737
Optics EXPRESS

Magneto-optical imaging of coherent spin dynamics in ferrites

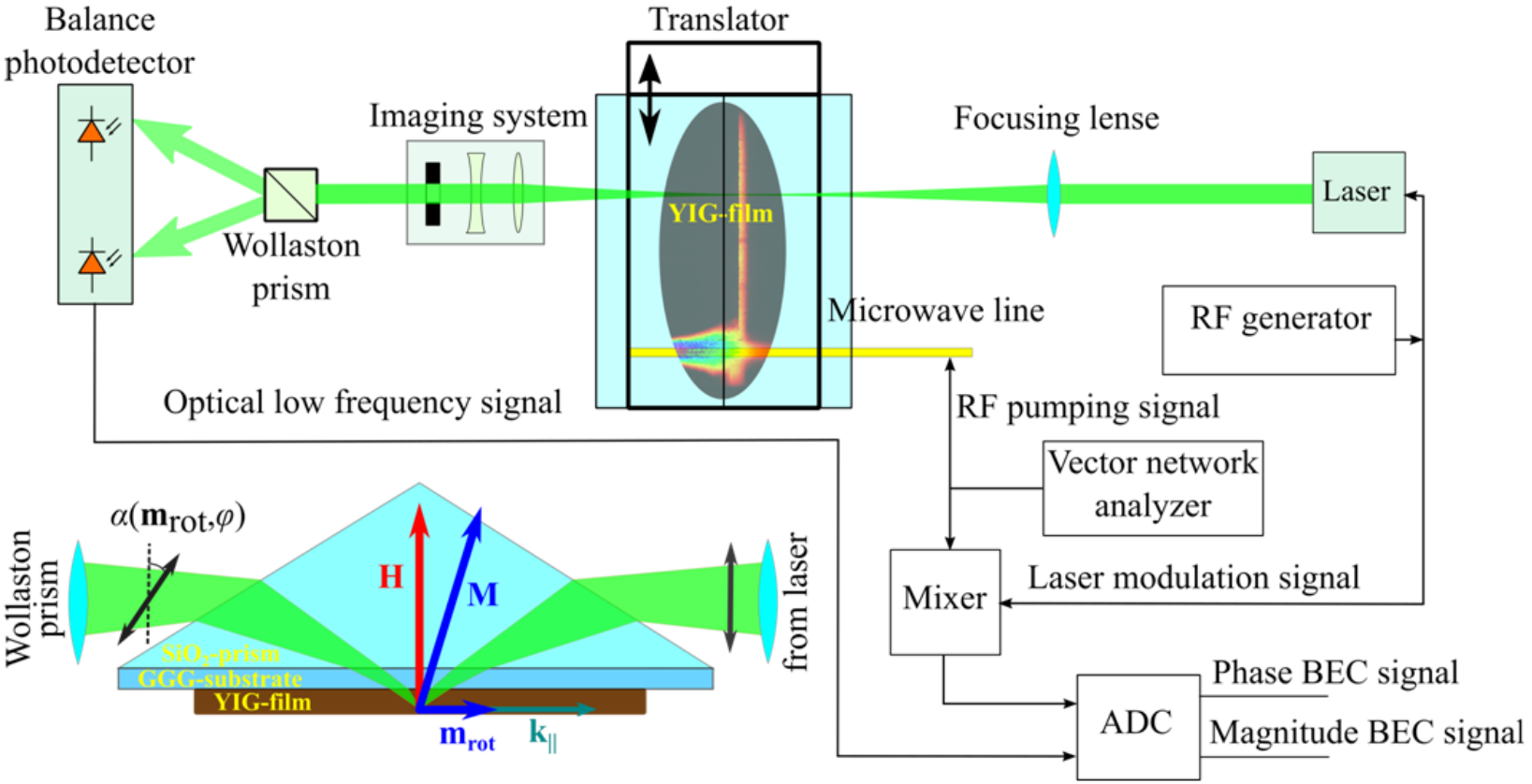
P. E Petrov,[1,2] P. O Kapralov,[1] G. A Knyazev,[1,2] A. N Kuzmichev,[1] P. M Vetoshko,[1,3,4] Yu. M Bunkov,[1,3,*] and V. I Belotelov[1,2,3]



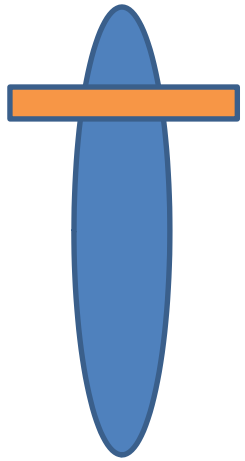
Faraday rotation

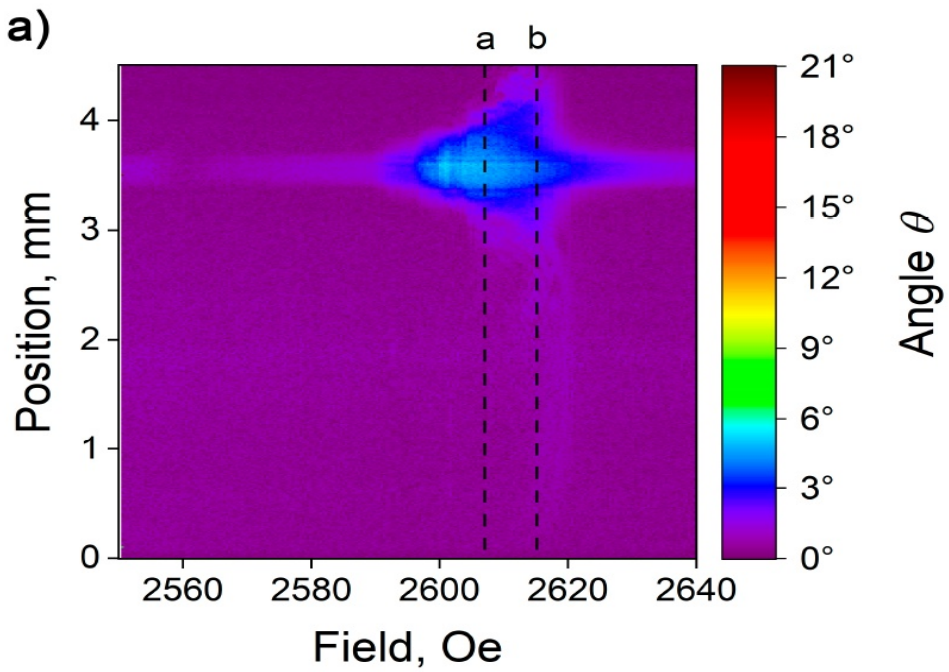


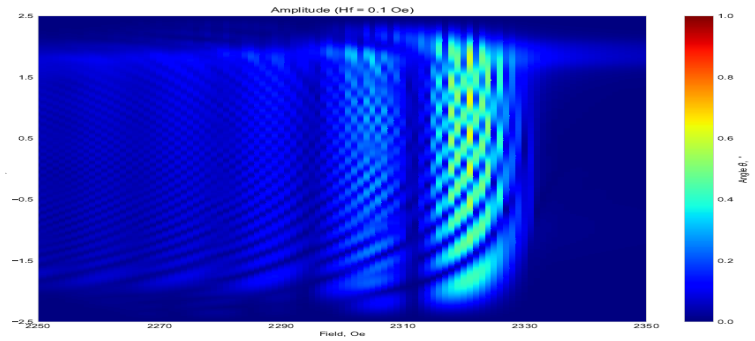
The difference between the frequencies of RF and the laser modulation is 12 kHz.

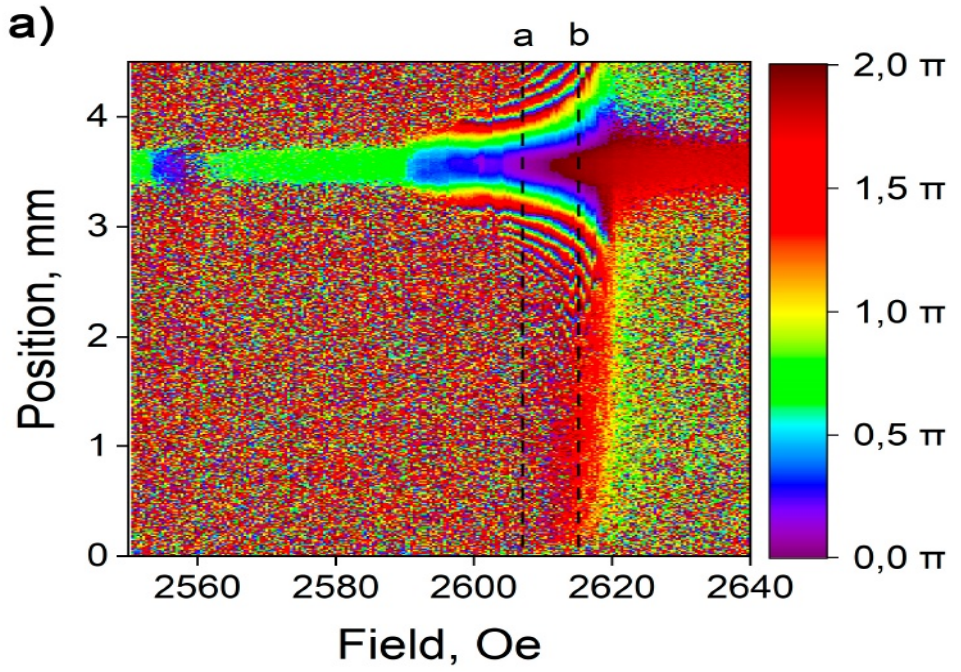


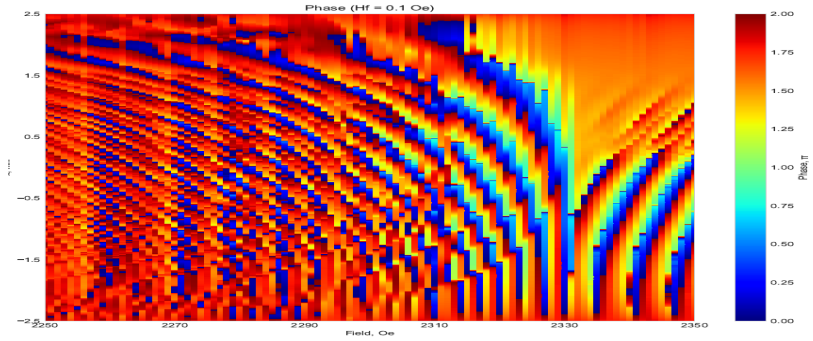
Spin Wave modes, small excitation



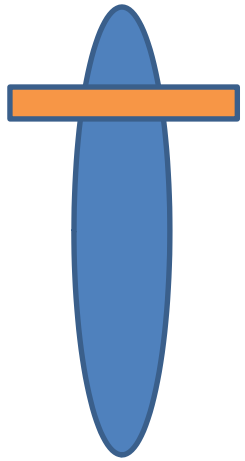


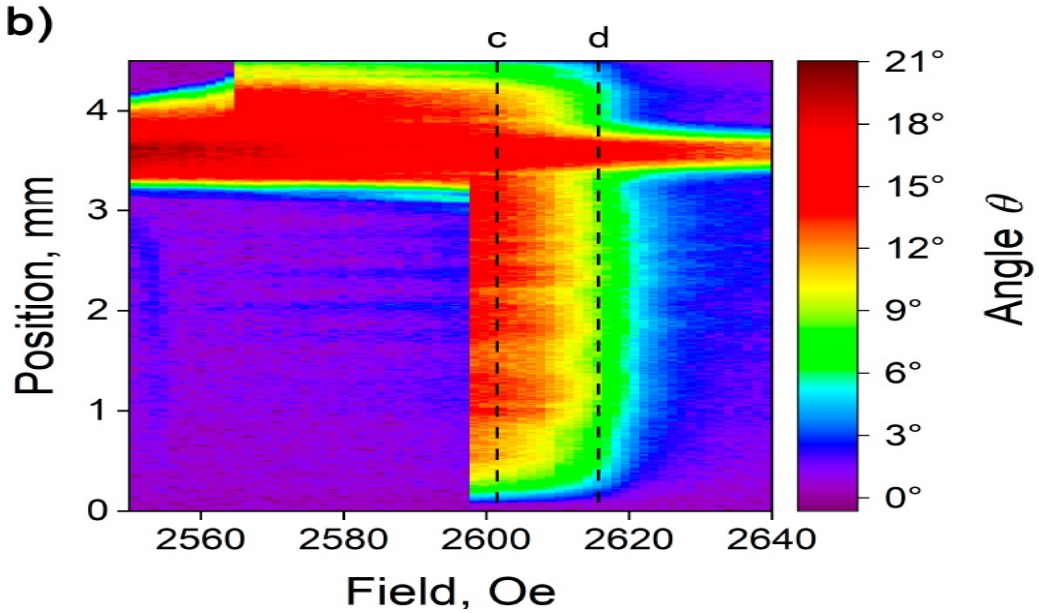


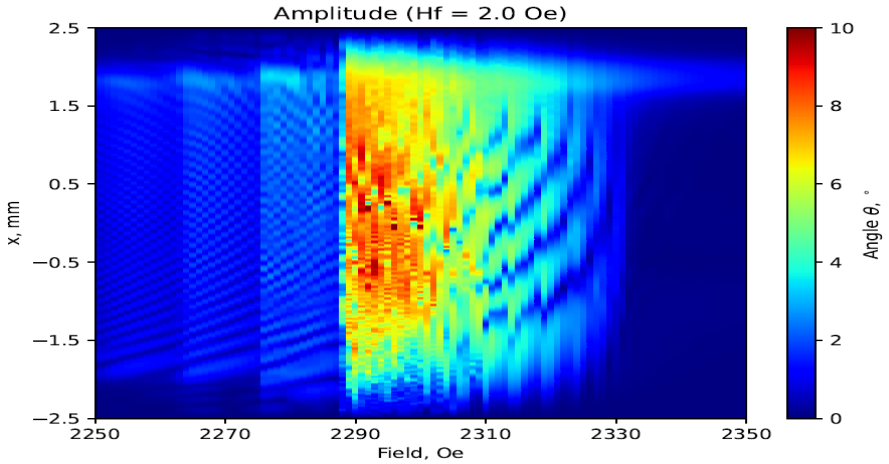


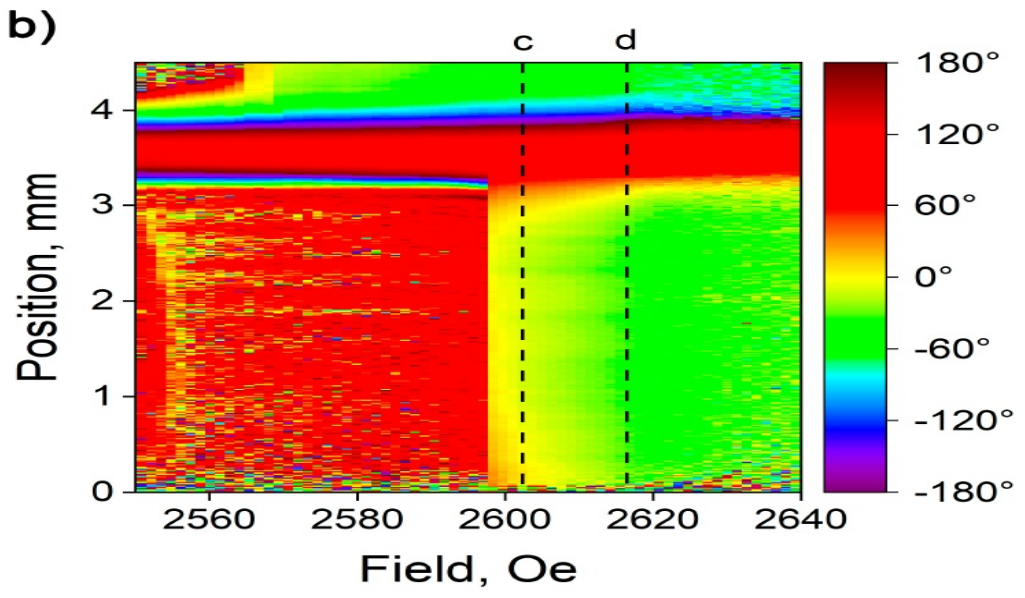


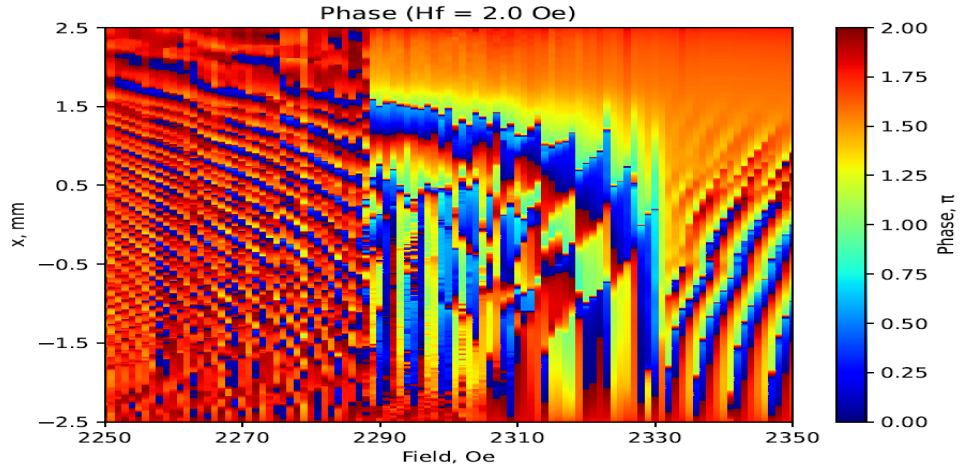
BEC mode, high excitation



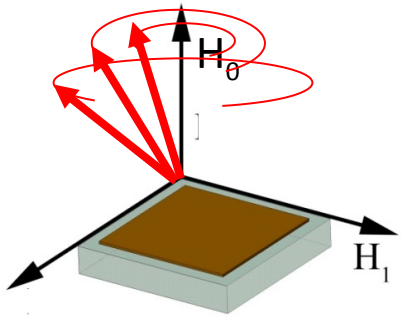


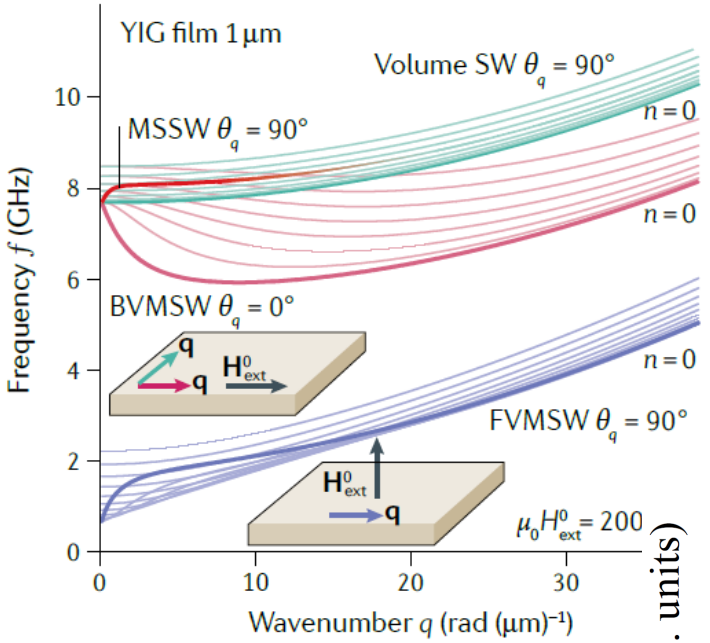


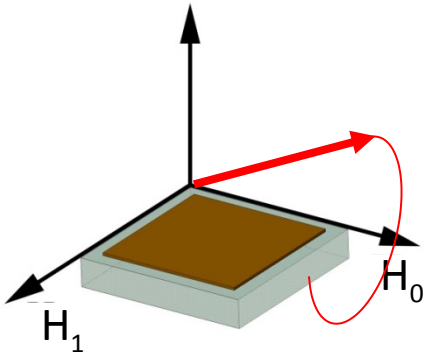


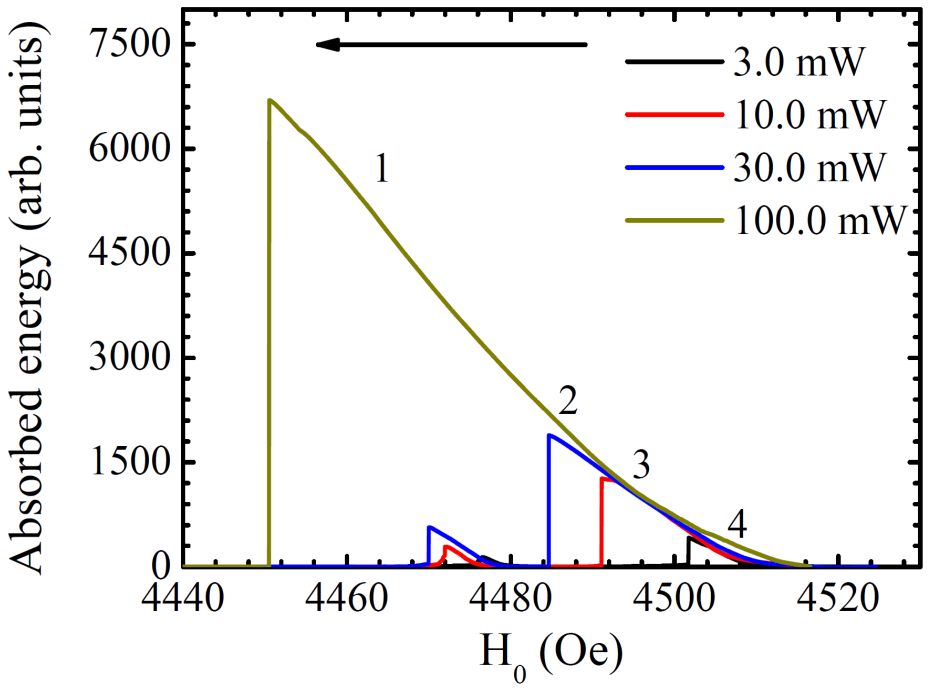


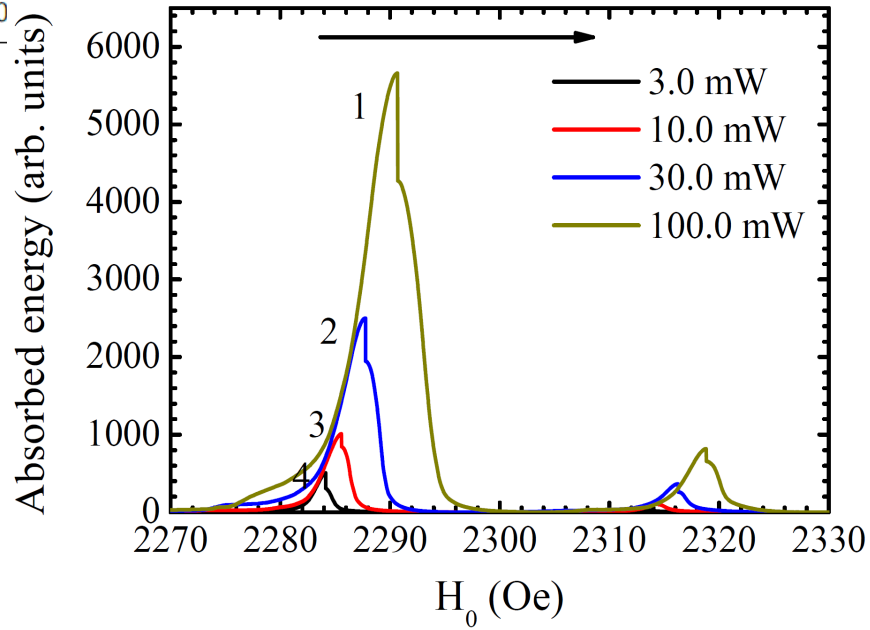
MBEC comparision



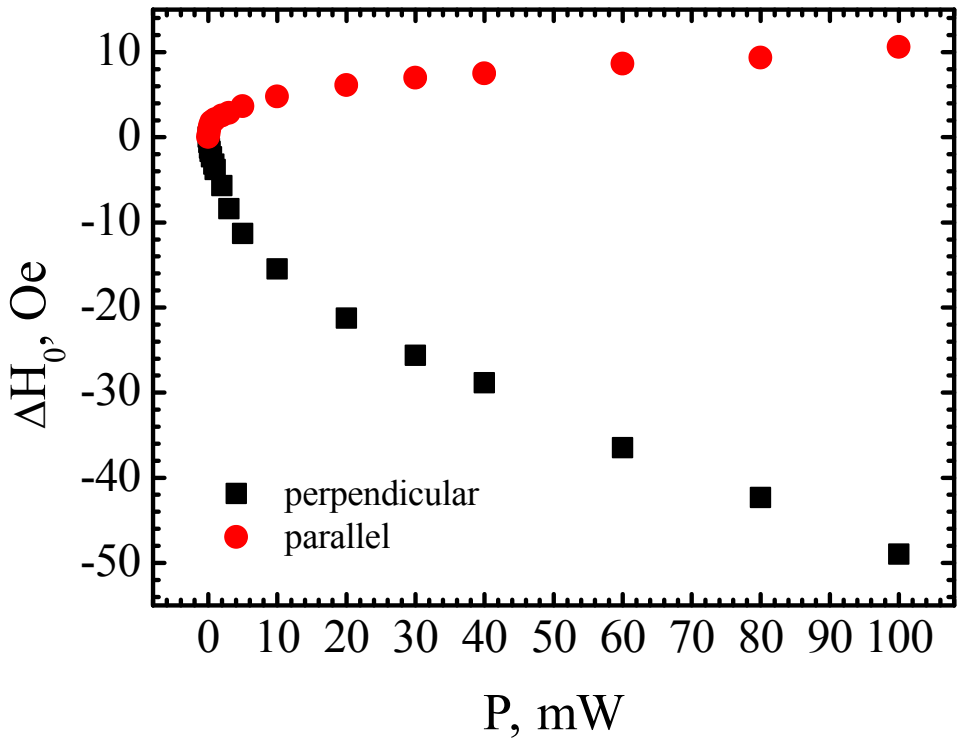


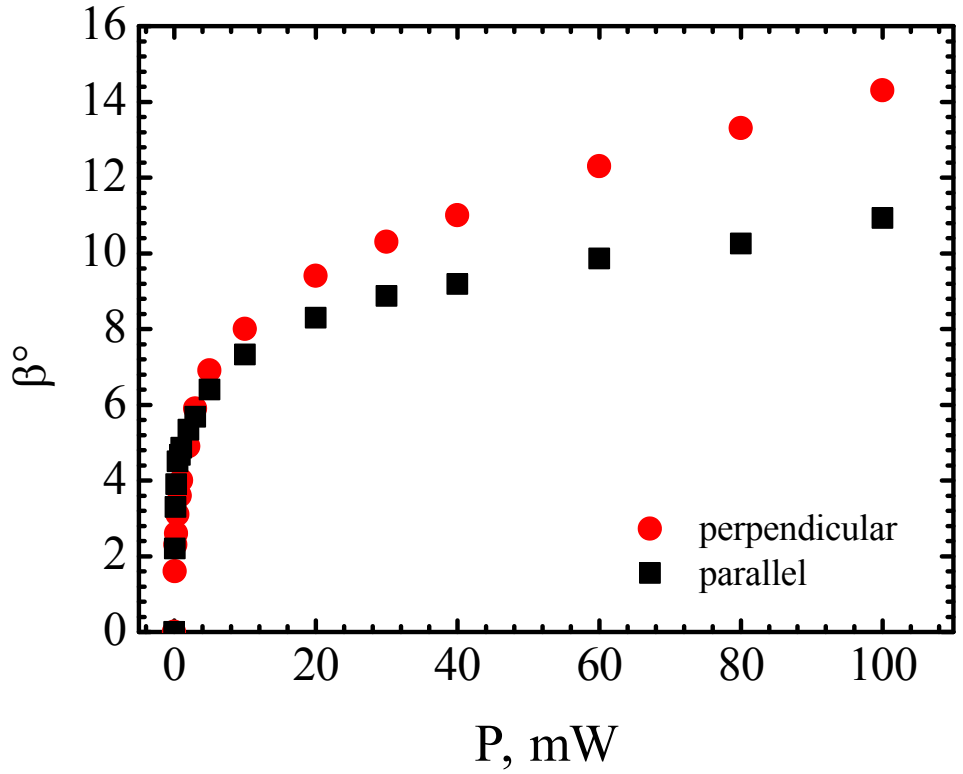






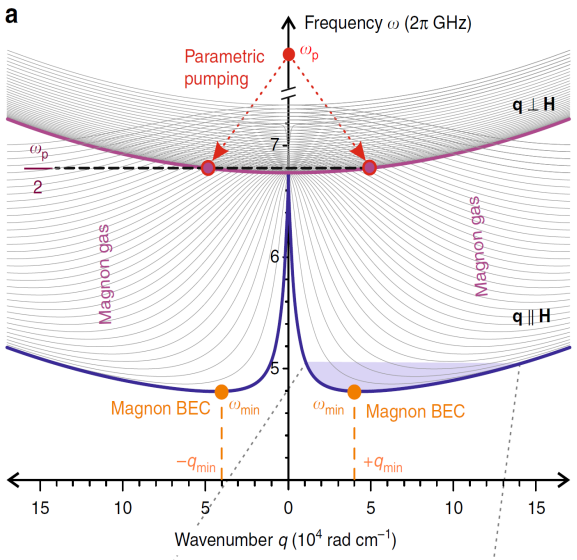
MBEC comparision





MBEC in Hillebrants group

Parametric pumping



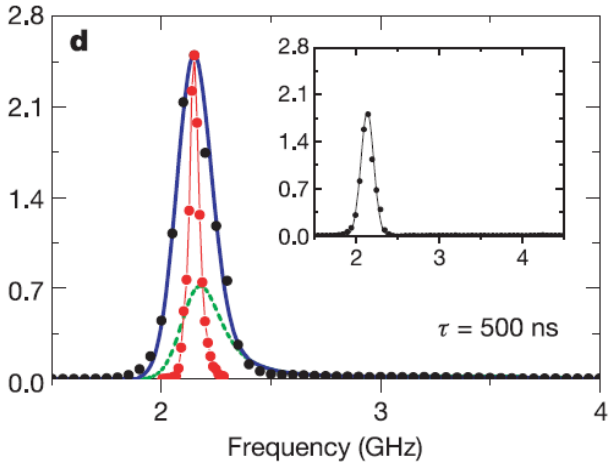
Nowik-Boltyk P, Dzyapko O, Demidov V E, Berloff N G and Demokritov S O 2012 *Sci. Rep.* **2** 482

nature Vol 443|28 September 2006|doi:10.1038/nature05117

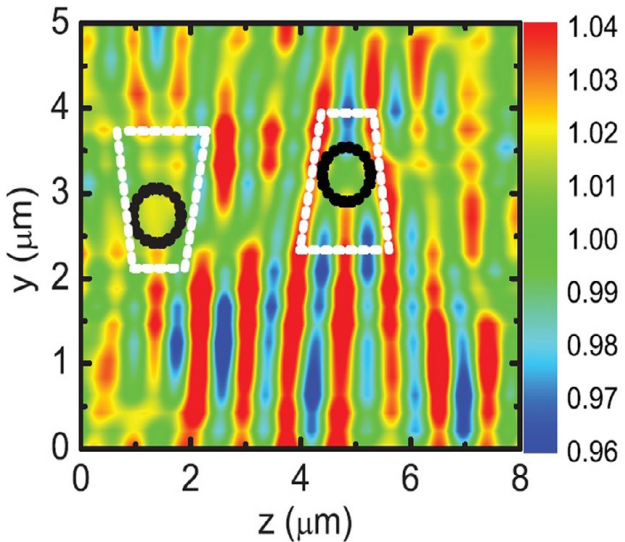
LETTERS

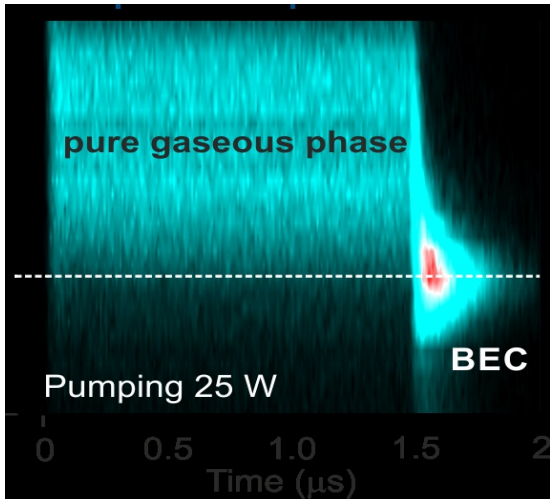
Bose–Einstein condensation of quasi-equilibrium magnons at room temperature under pumping

S. O. Demokritov[1], V. E. Demidov[1], O. Dzyapko[1], G. A. Melkov[2], A. A. Serga[3], B. Hillebrands[3] & A. N. Slavin[4]



Red circles in d indicate data obtained with a resolution of 50 MHz;





Hillebrants et all., Nature nanotechnology DOI:10.1038/s41565-020-0761-

Questions

1. The traveling spin waves with $k = 10^5$ 1/cm.
Can it be considered as Bose condensate or analogue of photon modes in a resonator?

2. Can magnons with mass anisotropy be considered a Bose condensate?

3. Does our spatially homogeneous coherent state of magnons go beyond the Landau-Lifshitz approximation?