Propagation of linear and nonlinear spin wave excitations in YIG and $Lu_{2.04}Bi_{0.96}Fe_5O_{12}$ films studied by space resolved Brillouin light scattering (abstract)

M. Bauer, C. Mathieu, S. O. Demokritov, and B. Hillebrands
Fachbereich Physik, Universität Kaiserslautern, Kaiserslautern 67663, Germany

P. A. Kolodin
Electrotechnical University, St. Petersburg, Russia

S. Sure and H. Dötsch
Fachbereich Physik, Universität Osnabrück, Osnabrück 49069, Germany

A. N. Slavin
Department of Physics, Oakland University, Rochester, Michigan 48309-4401

We have investigated the propagation of surface and backward volume spin waves (BVSW) with the in-plane wavevector $k_{\|} = 10–900\ cm^{-1}$ excited by microwaves in YIG and $Lu_{2.04}Bi_{0.96}Fe_5O_{12}$ (LBIG) films with the film thicknesses 5 and 1.5 μm, respectively. In all cases the magnetization and $k_{\|}$ were in the film plane. The frequencies of the spin wave excitations as well as the spatial distribution of their intensities in the linear and in the nonlinear excitation regime were measured by means of a fully automated, high-stabilization, small-angle Brillouin light scattering (BLS) setup with a spatial resolution of 30 μm. It is well known[1] that in the case of BVSW modes, the Lighthill criterion[2] for modulational instability is fulfilled for both the longitudinal and the transverse perturbations of the initially constant-amplitude wave beam. Therefore, this mode is very much suitable for the investigation of the evolution of a plane-front, constant-amplitude initial beam, and for a direct experimental study of two-dimensional nonlinear diffraction effects of the beam leading to self-focusing. The garnet films with in-plane dimensions of $2\times10\ mm^2$ were grown by liquid phase epitaxy onto a single crystalline (111)-oriented gallium gadolinium garnet substrate. Two strip antennas, 35 μm wide and situated at the ends of the films, were used for the excitation of the spin waves and for monitoring. The working frequency was 8.10 GHz. Special efforts were taken to minimize the beam divergence due to the finite length of the input antenna. For all nonlinear studies the initial angular beam divergence was not larger than $\Theta_{max}=0.05$ rad. In the linear regime the attenuation factor was measured, and the reflection of the spin waves from the sample boundaries was studied. We also observed the interference between the two lowest order lateral modes having different initial spatial distributions of the magnetization. The BLS technique was shown to provide a signal to noise ratio exceeding 60 dB. In the nonlinear regime the propagation of the BVSW mode was thoroughly investigated. We have found clear evidence for the self-focusing effect, which exists in a narrow interval of input powers. In these studies overheating of the sample by the microwave power was carefully avoided by using an intermittent source of maximum average power of 100 mW working at a frequency of 4 kHz. That allowed us to claim that the observed focusing of the spin waves was not an artifact caused by sample heating. The distance between the focusing maximum and the antenna was 1.5 mm for LBIG sample and 6 mm for YIG sample. These values are in a good agreement with our theoretical calculations, if one takes into account the thicknesses of the films. For a comparison of the observed values of the width and the length of the focusing spot and their dependence on the microwave power with the theory, more numerical calculations are needed. Our results demonstrate the wide applicability of an advanced combined microwave-BLS technique for a two-dimensional mapping of the spin wave amplitudes in the media. © *1997 American Institute of Physics.* [S0021-8979(97)53208-7]

[1] P. E. Wigen, *Nonlinear Phenomena and Chaos in Magnetic Materials* (World Scientific, Singapore, 1994), Chap. 9.
[2] M. J. Lighthill, J. Inst. Math. Appl. **1**, 269 (1965).