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Abstracts

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Hartman effect for spin waves in exchange regime

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The Hartman effect [1] is the wave phenomenon observed for the wave packet tunnelling through a barrier, where the evanescent solution of the wave equation exists. The effect can be defined as the saturation of the group delay with the increase in the barrier width [3]. This can be paradoxically interpreted as an unlimited growth of the propagation speed for the tunnelling wave packet. The Hartman effect was investigated in the past for different types of wave excitations like electromagnetic and electronic waves. In this Communication, we show the possibility of the existence of Hartman effect for exchange spin waves which tunnel through the barrier formed by a magnetic anisotropy field [4].

The Hartman effect is a phase sensitive effect. Therefore the appropriate formulation of the boundary conditions on the interface of the barrier is crucial. In our calculations, we take into account the general Barnas-Mills boundary conductions (which include the interface exchange stiffness) to calculate the transmission and group delay for spin waves.

To exemplify our findings, we performed calculations of the exchange spin wave tunnelling through the anisotropy barrier in CoFeB of variable thickness, covered by MgO.

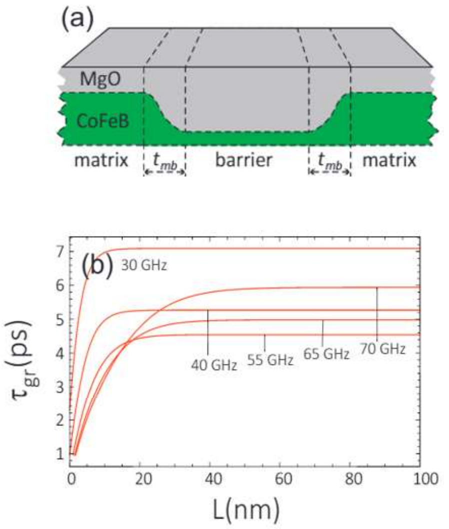

Figure 1. (a) The exemplary structure has the form of a ferromagnetic layer made of a low-damping material (CoFeB) with an out-of-plane magnetic anisotropy induced by the interface with the oxide layer (MgO) deposited on top of the ferromagnetic layer. (b) Saturation of the group delay τ_{gr}, observed in the tunnelling regime with the increase of the width of the barrier L. Width of the interface 'i' between the matrix 'm' (1.3nm thick) and the barrier 'b' (1.0nm thick) was assumed as t_{mb}=4 nm. The following material parameters were taken: $M_{S,m}$=1.2×10A/m, $M_{S,b}=0.8\times10^{6}$A/m, $A_m=27\times10^{12}$J/m, $A_b=20\times10^{12}$J/m, $K_i=1.3\times10^{-3}$J/m^3.

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References

[1] T.E. Hartman, J. Appl. Phys. **33**, 3427 (1962);
H.G. Winful, Phys. Rev. Lett. **90**, 023901 (2003).

[2] M. Büttiker and S. Washburn, Nature **422**, 271 (2003).

[3] J.W. Kłos, Y.S. Dadoenkova, J. Rychły, N. N. Dadoenkova, I.L. Lyubchanskii and J. Barnaś, arXiv:1801.05876.