ERC StG MagnonCircuits

Nano-scale magnonic circuits for novel computing systems

List of publications

1. *Fast long-wavelength exchange spin waves in partially-compensated Ga:YIG*
   T. Böttcher, M. Ruhwedel, K. O. Levchenko, Q. Wang, H. L. Chumak, M. A. Popov, I. V. Zavislyak, C. Dubs, O. Surzhenko, B. Hillebrands, A. V. Chumak, P. Pirro
   arXiv:2112.11348

2. *Roadmap on spin-wave computing*
   A. V. Chumak, P. Kabos, M. Wu, C. Albert, C. Adelman, A. Adeyeye, J. Åkerman, F. G. Aliev, A. Anane, A. Awad, C. H. Back, A. Barman, G. E. W. Bauer, M. Becherer, E. N. Beginin, V. A. S. V. Bittencourt, Y. M. Blanter, P. Bortolotti, I. Boventer, D. A. Bozhko, S. A. Bunyaev, J. J. Carmiggelt, R. R. Cheenikundil, F. Ciubotaru, S. Cotofana, G. Csaba, O. V. Dobrovolskiy, C. Dubs, M. Elyasi, K. G. Fripp, H. Fulara, I. A. Golovchanskiy, C. Gonzalez-Ballestero, P. Graczyk, D. Grundler, P. Gruszecki, G. Gubbiotti, K. Guslienko, A. Haldar, S. Hamdioui, R. Hertel, B. Hillebrands, T. Hioki, A. Houshang, C.-M. Hu, H. Huebl, M. Huth, E. Iacocca, M. B. Jungfleisch, G. N. Kakazei, A. Khitun, R. Khymyn, T. Kikkawa, M. Kläui, O. Klein, J. W. Kłos, S. Knauer, S. Koraltan, M. Kostylev, M. Krawczyk, I. N. Krivorotov, V. V. Kruglyak, D. Lachance-Quirion, S. Ladak, R. Lebrun, Y. Li, M. Lindner, R. Macêdo, S. Mayr, G. A. Melkov, S. Mieszczak, Y. Nakamura, H. T. Nembach, A. A. Nikitin, S. A. Nikitov, V. Novosad, J. A. Otalora, Y. Otani, A. Papp, B. Pigeau, P. Pirro, W. Porod, F. Porrati, H. Qin, B. Rana, T. Reimann, F. Riente, O. Romero-Isart, A. Ross, A. V. Sadovnikov, A. R. Safin, E. Saitoh, G. Schmidt, H. Schultheiss, K. Schultheiss, A.A. Serga, S. Sharma, J. M. Shaw, D. Suess, O. Surzhenko , K. Szulc, T. Taniguchi, M. Urbánek, K. Usami, A. B. Ustinov, T. van der Sar, S. van Dijken, V. I. Vasyuchka, R. Verba, S. Viola Kusminskiy, Q. Wang, M. Weides, M. Weiler, S. Wintz, S. P. Wolski, X. Zhang
   arXiv:2111.00365

3. *Numerical model for 32-bit magnonic ripple carry adder*
   U. Garlando, Q. Wang, O. V. Dobrovolskiy, A. V. Chumak, F. Riente
   arXiv:2109.12973

4. *Parametric generation of spin waves in nano-scaled magnonic conduits*
   B.Heinz, M. Mohseni, A. Lentfert, R. Verba, M.l Schneider, B. Lägel, K. Levchenko, T. Brächer, C. Dubs, A. V. Chumak, P. Pirro
   arXiv:2106.10727

5. *Cherenkov radiation of spin waves by ultra-fast moving magnetic flux quanta*
   O. V. Dobrovolskiy, Q. Wang, D. Yu. Vodolazov, B. Budinska, R. Sachser, A. V. Chumak, M. Huth, A. I. Buzdin
   arXiv:2103.10156

6. *Bose-Einstein condensation of a DC-pulse driven magnon systems*
   Michael Schneider
   PhD Dissertation (2021)

7. *Nano-scaled exchange magnonics*
   Björn Heinz
   PhD Dissertation (2021)

8. *Control of the Bose-Einstein condensation of magnons by the Spin Hall effect*
M. Schneider, D. Breitbach, R. Serha, Q. Wang, A. A. Serga, A. N. Slavin, V. S. Tiberkevich, B. Heinz, B. Lägel, T. Brächer, C. Dubs, S. Knauer, O. V. Dobrovolskiy, P. Pirro, B. Hillebrands, and A. V. Chumak
Phys. Rev. Lett. **127**, 237203 (2021) DOI: 10.1103/PhysRevLett.127.237203

9. *Stabilization of a nonlinear bullet coexisting with a Bose-Einstein condensate in a rapidly cooled magnonic system driven by a spin-orbit torque*
M. Schneider, D. Breitbach, R. O. Serha, Q. Wang, M. Mohseni, A. A. Serga, A. N. Slavin, V. S. Tiberkevich, B. Heinz, T. Brächer, B. Lägel, C. Dubs, S. Knauer, O. V. Dobrovolskiy, P. Pirro, B. Hillebrands, and A. V. Chumak
Phys. Rev. B **104**, L140405 (2021) DOI:10.1103/PhysRevB.104.L140405

10. *Tension-free Dirac strings and steered magnetic charges in 3D artificial spin ice*
S. Koraltan, F. Slanovc, F. Bruckner, C. Nisoli, A.V. Chumak, O.V. Dobrovolskiy, C. Abert, and D. Suess
npj Comput Mater 7, **125** (2021) DOI: 10.1038/s41524-021-00593-7

11. *The 2021 Magnonics Roadmap*
A. Barman, G. Gubbiotti, S. Ladak, A. O. Adeyeye , M. Krawczyk , J. Gräfe, C. Adelmann, S. Cotofana, A. Naeemi, V. I. Vasyuchka, B. Hillebrands, S. A. Nikitov, H. Yu, D. Grundler, A. V. Sadovnikov, A. A. Grachev, S. E. Sheshukova, J.-Y. Duquesne, M. Marangolo, G. Csaba, W. Porod, V. E. Demidov, S. Urazhdin, S. O. Demokritov, E. Albisetti, D. Petti, R. Bertacco, H. Schultheiss, V. V. Kruglyak, V. D. Poimanov, S. Sahoo, J. Sinha, H. Yang, M. Münzenberg, T. Moriyama, S. Mizukami, P. Landeros, R. A. Gallardo, G. Carlotti, J.-V. Kim, R. L. Stamps, R. E. Camley, B. Rana,Y. Otani, W. Yu, T. Yu, G. E. W. Bauer, C. Back, G. S. Uhrig, O. V. Dobrovolskiy, B. Budinska, H. Qin, S. van Dijken, A. V. Chumak, A. Khitun, D. E. Nikonov, I. A. Young, B. W. Zingsem, and M. Winklhofer,
J. Phys.: Condens. Matter **33**, 413001 (2021) DOI: 10.1088/1361-648X/abec1a

12. *Propagation of magnetostatic surface spin waves in YIG nano-structures*
Elisabeth Weiß
Master Thesis (2021)

13. *Inverse-design magnonic devices*
Q. Wang, A. V. Chumak, and P. Pirro
Nat. Commun. **12**, 2636 (2021) DOI: 10.1038/s41467-021-22897-4

14. *Spin-wave eigenmodes in direct-write 3D nanovolcanoes*
O. V. Dobrovolskiy, N. R. Vovk, A. V. Bondarenko, S. A. Bunyaev, S. Lamb-Camarena, N. Zenbaa, R. Sachser, S. Barth, K. Y. Guslienko, A. V. Chumak, M. Huth, and G. N. Kakazei
Appl. Phys. Lett. **118**, 132405 (2021) DOI: 10.1063/5.0044325

15. *Long-range spin-wave propagation in transversely magnetized nano-scaled conduits*
B. Heinz, Q. Wang, M. Schneider, E. Weiß, A. Lentfert, B. Lägel, T. Brächer, C. Dubs, O. V. Dobrovolskiy, P. Pirro, and A. V. Chumak
Appl. Phys. Lett. **118**, 132406 (2021) DOI: 10.1063/5.0045570

16. *Controlling the nonlinear relaxation of quantized propagating magnons in nanodevices*
M. Mohseni, Q. Wang, B. Heinz, M. Kewenig, M. Schneider, F. Kohl, B. Lägel, C. Dubs, A. V. Chumak, and P. Pirro
Phys. Rev. Lett. **126**, 097202 (2021) DOI: 10.1103/PhysRevLett.126.097202

17. *Recent trends in microwave magnetism and superconductivity (review)*
O. V. Prokopenko, D. A. Bozhko, V. S. Tyberkevych, A. V. Chumak, V. I. Vasyuchka, A. A. Serga, O.

Dzyapko, R. V. Verba, A. V. Talalaevskij, D. V. Slobodianiuk, Yu. V. Kobljanskyj, V. A. Moiseienko, S. V. Sholom, and V. Yu. Malyshev
Ukr. J. Phys. **64**, 888 (2019) DOI: 10.15407/ujpe64.10.888

18. *Opportunities and challenges for spintronics in the microelectronics industry*
B. Dieny, I. L. Prejbeanu, K. Garello, P. Gambardella, P. Freitas, R. Lehndorff, W. Raberg, U. Ebels, S.O. Demokritov, J. Akerman, A. Deac, P. Pirro, C. Adelmann, A. Anane, A. V. Chumak, A. Hirohata, S. Mangin, S. O. Valenzuela, M. Cengiz Onbaşli, M. d'Aquino, G. Prenat, G. Finocchio, L. Lopez-Diaz, R. Chantrell, O. Chubykalo-Fesenko, and P. Bortolotti
Nat. Electr. **3**, 446 (2020) DOI: 10.1038/s41928-020-0461-5

19. *Reflection-less width-modulated magnonic crystal*
P. Frey, A. A. Nikitin, D. A. Bozhko S. A. Bunyaev, G. N. Kakazei, A. V. Ustinov, B. A. Kalinikos, F. Ciubotaru, A. Chumak, Q. Wang, V. Tiberkevich, B. Hillebrands, and A. A. Serga
Commun. Phys. **3**, 17 (2020) DOI: 10.1038/s42005-020-0281-y

20. *Magnon-phonon interactions in magnon spintronics* (review)
D. A. Bozhko, V. I. Vasyuchka, A. V. Chumak, and A. A. Serga
Low Temp. Phys. **46**, 383 (2020) DOI: 10.1063/10.0000872

21. *Propagating Magnetic Droplet Solitons as Moveable Nanoscale Spin-Wave Sources with Tunable Direction of Emission*
M. Mohseni, Q. Wang, M. Mohseni, T. Brächer, B. Hillebrands, and P. Pirro
Phys. Rev. Applied 13, 024040 (2020) DOI: 10.1063/5.0019328

22. *Introduction to spin wave computing (Tutorial Article)*
A. Mahmoud, F. Ciubotaru, F. Vanderveken, A. V. Chumak, S. Hamdioui, C. Adelmann, and S. Cotofana
J. Appl. Phys. **128**, 161101 (2020) DOI: 10.1063/5.0019328

23. *Temperature dependence of spin pinning and spin-wave dispersion in nanoscopic ferromagnetic waveguides*
B. Heinz, Q. Wang, R. Verba, V. I. Vasyuchka, M. Kewenig, P. Pirro, M. Schneider, T. Meyer, B. Lägel, C. Dubs, T. Brächer, O. V. Dobrovolskiy, and A. V. Chumak
Ukr. J. Phys. **65**, 1094 (2020) DOI: 10.15407/ujpe65.12.1094

24. *A nonlinear magnonic nano-ring resonator*
Q. Wang, A. Hamadeh, R. Verba, V. Lomakin, M. Mohseni, B. Hillebrands, A. V. Chumak, and P. Pirro
npj Comput. Mater. **6**, 192 (2020) DOI: 10.1038/s41524-020-00465-6

25. *Propagation of coherent spin-wave packets in individual nanosized yttrium iron garnet magnonic conduits*
B. Heinz, T. Brächer, M. Schneider, Q. Wang, B. Lägel, A. M. Friedel, D. Breitbach, S. Steinert, T. Meyer, M. Kewenig, C. Dubs, P. Pirro, and A. V. Chumak
Nano Lett. **20**, 4220 (2020) DOI: 10.1021/acs.nanolett.0c00657

26. *Spin-wave spectroscopy of individual ferromagnetic nanodisks*
O. V. Dobrovolskiy, S. A. Bunyaev, N. R. Vovk, D. Navas, P. Gruszecki, M. Krawczyk, R. Sachser, M. Huth, A. V. Chumak, K. Y. Guslienko, and G. N. Kakazei
Nanoscale **12**, 21207 (2020) DOI: 10.1039/D0NR07015G

27. *Bose–Einstein condensation of quasiparticles by rapid cooling*
M. Schneider, T. Brächer, D. Breitbach, V. Lauer, P. Pirro, D. A. Bozhko, H. Yu. Musiienko-Shmarova, B. Heinz, Q. Wang, T. Meyer, F. Heussner, S. Keller, E. Th. Papaioannou, B. Lägel, T. Löber, C. Dubs, A.

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28. *Parametric generation of propagating spin waves in ultrathin yttrium iron garnet waveguides*
M. Mohseni, M. Kewenig, R. Verba, Q. Wang, M. Schneider, B. Heinz, C. Dubs, A. A. Serga, B. Hillebrands, A. V. Chumak, and P. Pirro
Phys. Status Solidi (RRL) **14**, 2000011 (2020) DOI: 10.1002/pssr.202000011

29. *Ultra-fast vortex motion in a direct-write Nb-C superconductor*
O. V. Dobrovolskiy, D. Yu. Vodolazov, F. Porrati, R. Sachser, V. M. Bevz, M. Yu. Mikhailov, A. V. Chumak, and M. Huth
Nat. Commun. **11**, 3291 (2020) DOI: 10.1038/s41467-020-16987-y

30. *A magnonic directional coupler for integrated magnonic half-adders*
Q. Wang, M. Kewenig, M. Schneider, R. Verba, F. Kohl, B. Heinz, M. Geilen, M. Mohseni, B. Lägel, F. Ciubotaru, C. Adelmann, C. Dubs, S. D. Cotofana, O. V. Dobrovolskiy, T. Brächer, P. Pirro, and A. V. Chumak,
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31. *Detektion von Spinwellendynamik in YIG/Schwermetall Nano-Schichtsystemen*
S. Steinert
Diploma Thesis (2019)

32. *Linear and Nonlinear Spin Waves in Nanoscale Magnonic Structures for Data Processing*
Q. Wang
PhD Dissertation (2019)

33. *Magnon spintronics: Fundamentals of magnon-based computing*
A. V. Chumak
In: *Spintronics Handbook: Spin Transport and Magnetism*, Second Edition,
E. Y. Tsymbal and I. Žutić (eds.), CRC Press, Boca Raton, Florida), Chapter 6, pp. 247-302, (2019)
ISBN 9781498769723 - CAT# K29316
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34. *Backscattering Immunity of Dipole-Exchange Magnetostatic Surface Spin Waves*
M. Mohseni, R. Verba, T. Brächer, Q. Wang, D. A. Bozhko, B. Hillebrands, and P. Pirro
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35. *Nanoscale spin-wave wake-up receiver*
Q. Wang, T. Brächer, M. Mohseni, B. Hillebrands, V. I. Vasyuchka, A. V. Chumak, and P. Pirro
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36. *Spin pinning and spin-wave dispersion in nanoscopic ferromagnetic waveguides*
Q. Wang, B. Heinz, R. Verba, M. Kewenig, P. Pirro, M. Schneider, T. Meyer, B. Lägel, C. Dubs, T. Brächer, and A. V. Chumak
Phys. Rev. Lett. **122**, 247202 (2019) DOI: 10.1103/PhysRevLett.122

37. *The SpinTronicFactory roadmap: a European community view*
B. Dieny, L. Prejbeanu, K. Garello, P. Freitas, R. Lehndorff, W. Raberg, U. Ebels, S. Demokritov, J. Akerman, P. Pirro, C. Adelmann, A. Anane, A. Chumak, A. Hiroata, S. Mangin, M. d'Aquino, G. Prenat, G. Finocchio, L. Lopez Diaz, O. Chubykalo-Fesenko, P. Bortolotti
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38. *Magnon-Fluxon interaction in a ferromagnet/superconductor heterostructure*
O. V. Dobrovolskiy, R. Sachser, T. Brächer, T. Fischer, V. V. Kruglyak, R. V. Vovk, V. A. Shklovskij,

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39. *Optical determination of the exchange stiffness constant in an iron garnet*
K. Matsumoto, T. Brächer, P. Pirro, T. Fischer, D. Bozhko, M. Geilen, F. Heussner, T. Meyer, B. Hillebrands and T. Satoh
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40. *An analog magnon adder for all-magnonic neurons*
T. Brächer and P. Pirro
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41. *Reconfigurable nano-scale spin-wave directional coupler*
Q. Wang, P. Pirro, R. Verba, A. Slavin, B. Hillebrands, and A. V. Chumak
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42. *Magnonics: spin waves connecting charges, spins and photons* (review)
A. V. Chumak and H. Schultheiss
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43. *Magnonic crystals for data processing* (review)
A. V. Chumak, A.A. Serga, and B. Hillebrands
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44. *Voltage-controlled nanoscale reconfigurable magnonic crystal*
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45. *Experimental prototype of a spin-wave majority gate*
T. Fischer, M. Kewenig, D. A. Bozhko, A. A. Serga, I. I. Syvorotka, F. Ciubotaru, C. Adelmann, B. Hillebrands, and A. V. Chumak
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46. *Temporal evolution of auto-oscillations in a YIG/Pt microdisc driven by pulsed spin Hall effect-induced spin-transfer torque*
V. Lauer, M. Schneider, Th. Meyer, Th. Braecher, P. Pirro, B. Heinz, F. Heussner, B. Laegel, M. C. Onbasli, C. A. Ross, B. Hillebrands, and A. V. Chumak
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