Dr. Helgi Sigurðsson

Curriculum Vitae

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Orcid | 0000-0002-4156-4414
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Adiunkt
University of Warsaw
Faculty of Physics
ul. Pasteura 5
02-093 Warsaw
Poland

Research

My work involves optical microcavities, nonlinear photonics, unconventional physically-inspired computing strategies, and quantum light-matter interactions in low-dimensional heterostructures with a focus on the strong-coupling regime hosting hybrid light-matter modes known as exciton-polaritons. My expertise is to provide theoretical analysis and simulation of dynamics of exciton-polariton condensates which possess an abundance of interesting nonlinear and non-Hermitian physics. This includes optical logic gates, polaritonic neuromorphic computing, XY spin-glass simulators, polarization sensitive information transport, artificial lattice dynamics, non-Hermitian topological physics, quantised vortices, solitons, domain walls, skyrmions, multistability, limit cycle dynamics, and bifurcation points.

Employment

April 2023 - Current:
Adiunkt | University of Warsaw | Faculty of Physics.

April 2023 - Current:
Researcher (joint appointment) | University of Iceland | Science Institute.

February 2021 - March 2023:
Post-Doctoral researcher | University of Iceland | Science Institute.

October 2018 - May 2023:
Research Fellow | University of Southampton | School of Physics and Astronomy | Hybrid Photonics Laboratories.

May 2016 - September 2018:
Post-Doctoral researcher | University of Iceland | Science Institute.

Education

2013 - 2016:
Doctor of Philosophy in research physics. School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore — Graduated 12th of December 2016.
Title of thesis: Nanostructures with quantized angular momentum in the strong light-matter coupling regime.
Supervisor: Prof. Ivan Shelykh

2009 - 2012:
B.Sc. in physics (180 ECTS). Faculty of Physical Sciences, University of Iceland *(Háskóli Íslands)*, Graduated with First Class, 23rd of June 2012.

Languages:
Icelandic - Proficient. **English** - Proficient. **Polish** - Conversational (A1).

Related Experience

Review duties

I have reviewed $>$ 100 grant proposals and research studies for: **UK Engineering and Physical Sciences Research Council — Nature — Nature Physics — Scientific Reports — Physical Review X — Physical Review Letters — Physical Review Applied — Physical Review B — Physical Review A — Physical Review Research — ACS Photonics —- APL Photonics — Optics Letters —Optics Express — Optical Material Express — Laser & Photonics Review — Elsevier Optik**.

Conference organisation

- **Chair and local organiser** of the 1st International Conference on Physics of Excitons and Polaritons in Semiconductors, Reykjavík, Iceland, August 2024.
- **Organising committtee member** of the 12th International Conference on Spontaneous Coherence in Excitons, Dublin, Ireland, June 2024.
- **Scientific secretary** of the 23rd International Conference on Physics of Light-Matter Coupling in Nanostructures, Medellín, Colombia, April 2023.

Funding and awards

April 2023 - Ongoing:
Research fellowship, Polish National Science Centre - Polonez Bis 2. Project: *Interacting Networks of Liquid Light* - 964.578 PLN (est. 205.000 EUR).

February 2023 - Ongoing:
Project Grant, Icelandic Research Fund. Project: *Interacting Networks of Liquid Light* - 53.000.000 ISK (est. 345.000 EUR).

February 2021 - February 2023:
Postdoctoral fellowship, Icelandic Research Fund. Project: *Polaritonic Neuromorphic Computing* - 27.000.000 ISK (est. 176.000 EUR).

January 2013 - May 2016:
PhD scholarship through The Singapore International Graduate Award (SINGA) with Agency for Science, Technology & Research (A*STAR) - est. 150.000 GPB.

Programming

Primary programming language:
MATLAB: Experience in solving nonlinear ODEs and PDEs using FFT spectral methods and linear multistep method.
LaTeX: Highly experienced in writing scientific articles, essays, and letters using the LaTeX typeset language.

Secondary programming languages:
Fortran(95), and Wolfram Mathematica: Highlight on fast numerical diagonalization techniques and scattering/transfer matrix strategies.

Soft skill training

November 2023: "Building a Doctoral Research Community" (1 hour), organised by University of Iceland, Graduate School | Centre for Research in the Humanities.

October 2023: "International Good Practice in PhD Supervision" (6 hours), organised by Vitae, ©Careers Research and Advisory Centre Limited on behalf of Euraxess, with the cooperation of Rannís and the University of Iceland Graduate School.

May 2023: "Masterclass on Scientific Innovation" (32 hours), organised by TTO Iceland; and Rannís.

July 2022: Research Concordat Events (2 hours): "Microaggressions: a risk for everyone", organised by Faculty of Engineering and Physical Sciences, University of Southampton, UK.

June 2022: Research Concordat Events (2 hours): "Taking the Chair", organised by Faculty of Engineering and Physical Sciences, University of Southampton, UK.

May 2022: *Skillfluence* course (5 hours): "A Guide to Virtual Networking", organised by the South East Physics Network, UK.

November 2021: GRADnet webinar (2 hours): "Developing knowledge and skills in Public Engagement", organised by the South East Physics Network, UK.

June 2021: Online Workshop (6 hours): *International Good Practices in Doctoral Supervision*, organised by Vitae, ©Careers Research and Advisory Centre Limited; the Icelandic Research Fund; Euraxis; and University of Iceland.

March 2021: Online Workshop (2 hours): *Quick Start Guide to Connecting with Industry*, organised by University of Southampton Impact Funding Team.

February 2021: Online Workshop (20 hours): *Teams, communication and leadership*, a GRADnet (UK) Winter School.

Januar 2021: *Negotiation Training* (8 hours), organised by University of Southampton Faculty of Engineering and Physical Sciences.

References Available to Contact

Prof. Ivan A. Shelykh
University of Iceland - Faculty of Physical Sciences - Iceland
ITMO University - Russian Federation
E-mail: shelykh@hi.is
Phone: +(354) 525 5959

Assoc. Prof. Timothy C. H. Liew
Nanyang Technological University - School of Mathematical and Physical Sciences - Singapore.
E-mail: TimothyLiew@ntu.edu.sg
Phone: +(65) 6316 2962

Prof. Pavlos G. Lagoudakis
University of Southampton - School of Physics and Astronomy - United Kingdom
Skolkovo Institute of Science and Technology - Russian Federation
E-mail: pavlos.lagoudakis@soton.ac.uk
Phone: +(44) 23 8059 9030

Prof. Barbara Piętka
University of Warsaw - Faculty of Physics - Poland
E-mail: barbara.pietka@fuw.edu.pl
Phone: (+48) 225 532 764

Publications

1. Optically driven spin precession in polariton condensates, Preprint arXiv:2305.03782
2. All-optical artificial vortex matter in quantum fluids of light, Preprint arXiv:2207.01850
3. Dirac exciton-polariton condensates in photonic crystal gratings, Nanophotonics (2024)
4. All-optical triangular and honeycomb lattices of exciton-polaritons - Appl. Phys. Lett. **124**, 062105 (2024)
5. Vortex clusters in a stirred polariton condensate, Phys. Rev. B **109**, 104503 (2024)
6. Occupancy-driven Zeeman suppression and inversion in trapped polariton condensates, Phys. Rev. B **109**, 125307 (2024) - **Editor's suggestion**
7. Reconfigurable quantum fluid molecules of bound states in the continuum, Nature Physics **20**, 61 (2024)
8. Next nearest neighbour coupling with spinor polariton condensates, Phys. Rev. B Letter **108**, L161301 (2023)
9. Reservoir microlensing in polariton condensates, Appl. Phys. Lett. **123**, 121101 (2023)
10. Polariton vortex Chern insulator **[Invited]**, Opt. Mater. Express **13**, 2550 (2023)
11. Magneto-optical induced supermode switching in quantum fluids of light, Communications Physics **6**, 196 (2023).
12. Quantum Vortex Formation in the "Rotating Bucket" Experiment with Polariton Condensates, Science Advances **9**, eadd1299 (2023).
13. Minor embedding with Stuart-Landau oscillator networks, Phys. Rev. Research **5**, 013018 (2023).

14. Enhanced coupling between ballistic polariton condensates through tailored pumping, Phys. Rev. B **106**, 245304 (2022).
15. Electrically tunable Berry curvature and strong light-matter coupling in birefringent perovskite microcavities at room temperature, Science Advances **8**, eabq7533 (2022).
16. Coherence Revivals of a Spinor Polariton Condensate from Self-induced Larmor Precession, Phys. Rev. Lett. **129**, 155301 (2022). - **Featured in Physics** and **Editors' Suggestion**
17. Spontaneous Formation of Time-Periodic Vortex Cluster in Nonlinear Fluids of Light, Phys. Rev. Lett. **128**, 237402 (2022). - **Featured on the issue's cover**
18. Screening nearest-neighbor interactions in networks of exciton-polariton condensates through spin orbit coupling, Phys. Rev. B **105**, 155306 (2022).
19. Solving the max-3-cut problem using synchronized dissipative networks, Phys. Rev. Applied **17**, 024063 (2022).
20. Engineering photon statistics in a spinor polariton condensate, Phys. Rev. Lett. **128**, 087402 (2022).
21. Machine learning of phase transitions in nonlinear polariton lattices, Communications Physics **5**, 8 (2022).
22. Reservoir optics with exciton-polariton condensates, Phys. Rev. B **104**, 235306 (2021).
23. Realizing Optical Persistent Spin Helix and Stern-Gerlach Deflection in an Anisotropic Liquid Crystal Microcavity, Phys. Rev. Lett. **127**, 190401 (2021). - **Editors' Suggestion**
24. Quantum fluids of light in all-optical scatterer lattices, Nature Communications **12**, 5571 (2021).
25. All-Optical Linear-Polarization Engineering in Single and Coupled Exciton-Polariton Condensates, Phys. Rev. Applied **16**, 034014 (2021).
26. Geometric frustration in polygons of polariton condensates creating vortices of varying topological charge, Nature Communications **12**, 2120 (2021).
27. Polariton spin jets through optical control, Phys. Rev. B **103**, 155302 (2021).
28. Optically controlled polariton condensate molecules, Phys. Rev. B **103**, 115309 (2021).
29. Photonic Berry curvature in double liquid crystal microcavities with broken inversion symmetry, Phys. Rev. B **103**, L081406 (2021).
30. Observation of second order meron polarisation textures in optical microcavities, Optica **8**, 255 (2021).
31. Engineering spatial coherence in lattices of polariton condensates, Optica **8**, 106 (2021).
32. Lotka-Volterra population dynamics in coherent and tunable oscillators of trapped polariton condensates, Phys. Rev. B **102**, 195428 (2020).
33. Hysteresis in linearly polarized nonresonantly driven exciton-polariton condensates, Phys. Rev. Research **2**, 023323 (2020).
34. Optical orientation, polarization pinning, and depolarization dynamics in optically confined polariton condensates, Phys. Rev. B **102**, 125419 (2020).
35. Synthetic band-structure engineering in polariton crystals with non-Hermitian topological phases, Nature Communications **11**, 4431 (2020).
36. Synchronization in optically trapped polariton Stuart-Landau networks, Phys. Rev. B **101**, 155402 (2020).
37. Optical Control of Couplings in Polariton Condensate Lattices, Phys. Rev. Lett. **124**, 207402 (2020). - **Featured on the issue's cover**
38. Time delay polaritonics, Communications Physics **3**, 2 (2020).
39. Spontaneous topological transitions in a honeycomb lattice of exciton-polariton condensates due to spin bifurcations, Phys. Rev. B **100**, 235444 (2019).
40. Probabilistic solving of NP-hard problems with bistable nonlinear optical networks, Phys. Rev. B **99**, 195301 (2019).
41. Amplification of Nonlinear Polariton Pulses in Waveguides, Optics Express **27**, 10692 (2019).
42. Observation of inversion, hysteresis, and collapse of spin in optically trapped polariton condensates, Phys. Rev. B **99**, 165311 (2019).
43. Optically trapped polariton condensates as semiclassical time crystals, Phys. Rev. A **99**, 033830 (2019).
44. Spin Domains in One-Dimensional Conservative Polariton Solitons, ACS Photonics **5**, 5095—5102 (2018).
45. All-to-All Intramodal Condensate Coupling by Multifrequency Excitation of Polaritons, ACS Photonics **6**, 123—129 (2018).

46. Transition from propagating polariton solitons to a standing wave condensate induced by interactions, Phys. Rev. Lett. **120**, 167402 (2018). - **Editors' Suggestion**
47. Parity bifurcations in trapped multistable phase locked exciton-polariton condensates, Phys. Rev. B **97**, 075305 (2018).
48. Spin Order and Phase Transitions in Chains of Polariton Condensates, Phys. Rev. Lett. **119**, 067401 (2017).
49. Driven-dissipative spin chain model based on exciton-polariton condensates, Phys. Rev. B **96**, 155403 (2017).
50. Parity solitons in nonresonantly driven-dissipative condensate channels, Phys. Rev. B **96**, 205406 (2017).
51. Spontaneous and superfluid chiral edge states in exciton-polariton condensates, Phys. Rev. B **96**, 115453 (2017).
52. Electrical and optical switching in the bistable regime of an electrically injected polariton laser, Phys. Rev. B **96**, 041301(R) (2017).
53. Nanostructures with quantized angular momentum in the strong light-matter coupling regime, Nanyang Technological University Open Repository (2016).
54. Half-skyrmion spin textures in polariton microcavities, Phys. Rev. B **94**, 045315 (2016).
55. Switching waves in multi-level incoherently driven polariton condensates, Phys. Rev. B **92**, 195409 (2015).
56. Polariton spin whirls, Phys. Rev. B **92**, 155308 (2015).
57. Aharonov–Bohm effect induced by circularly polarized light, Superlattices and Microstructures, **87**, 149-153, (2015).
58. Aharonov-Bohm effect for excitons in a semiconductor quantum ring dressed by circularly polarized light, Phys. Rev. B **91**, 235308 (2015).
59. Optically induced Aharonov-Bohm effect in mesoscopic rings, Phys. Rev. B **90**, 235413 (2014).
60. Information processing with topologically protected vortex memories in exciton-polariton condensates, Phys. Rev. B **90**, 014504 (2014).
61. Vortices in spinor cold exciton condensates with spin-orbit interaction, Phys. Rev. B **89**, 035302 (2014).

Conference and seminar contributions

September, 2023: Invited talk at the International Workshop on Polaritons in Emerging Materials - *Daejeon, South Korea*. Subject: *Optically spin-stirred cavity polariton condensates in a "rotating bucket" experiment.*

June, 2023: Contributed talk at the 51st International School & Conference on the Physics of Semiconductor (Jaszowiec) - *Szczyrk, Poland*. Subject: *Networks of liquid light.*

June, 2023: Contributed talk at the International Conference on Optics of Excitons in Confined Systems (OECS-18) - *Lecce, Italy*. Subject: *Spin hysteresis in driven linearly polarized cavity-polariton fluids.*

December, 2022: Invited talk at the International Conference on Terahertz Emission Metamaterials and Nanophotonics (TERAMETANANO-5) - *Natal, Brazil*. Subject: *Probing long-time dynamics in optically trapped exciton-polariton condensates.*

November, 2022: Invited talk at the IEEE Photonics Conference - *Vancouver, Canada*. Subject: *Liquid Light Computing: from logic to analogue simulation.*

August, 2022: Contributed talk at the International Conference on Spontaneous Coherence in Excitonic systems (ICSCE 11) - *Burlington VT, USA*. Subject: *Applying quantum computing minor embedding architectures in oscillatory networks of polariton condensates for max-3-cut solving.*

June, 2022: Contributed talk at Jaszowiec International School & Conference on the Physics of Semiconductors - *Szczyrk, Poland*. Subject: *Probing long-time dynamics in optically trapped exciton-polariton condensates.*

April, 2022: Contributed talk at the International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN22) - *Varadero, Cuba*. Subject: *Probing long-time dynamics in optically trapped exciton-polariton condensates .*

December, 2021: Seminar at the University of Warsaw - *Warsaw, Poland*. Subject: *Networks of liquid light.*

November, 2021: Invited talk at the Wilhelm and Else Heraeus Seminar - *Bad Honnef, Germany*. Subject: *Networks of liquid light.*

August, 2021: Poster presentation at the International Conference Optics of Excitons in Confined Systems (OECS 17) - *Dortmund, Germany*. Subject: *Lotka-Volterra dynamics in coherent and tunable oscillators of trapped polariton condensates .*

January, 2020: Contributed talk at the 10th International Conference on Spontaneous Coherence in Excitonic Systems (ICSCE10) - *Melbourne, Australia*. Subject: *Engineering interactions in networks of polariton condensates and the prospect of neural architectures.*

January, 2020: Seminar at Nanyang Technological University, - *Singapore*. Subject: *Optical sculpting and interactions between ballistic polariton condensates.*

September, 2019: Contributed talk at the International Conference on Optics of Excitons in Confined Systems (OECS 2019) - *St. Petersburg, Russia*. Subject: *Time delay polaritonics.*

July, 2019: Contributed talk at the International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN20) - *Suzdal, Russia*. Subject: *Geometrically induced circulating flows in polariton condensates.*

June, 2019: Seminar at University of Wolverhampton, - *Wolverhampton, UK*. Subject: *Time Delay Polaritonics.*

June, 2019: Contributed talk at the Workshop of Non-Equilibrium Phenomena in Superfluid and Coherent Quantum Systems - *Newcastle, UK*. Subject: *Time Delay Polaritonics.*

May, 2019: Contributed talk at the International Conference on Terahertz Emission Metamaterials and Nanophotonics (TERAMETANANO-3) - *Lecce, Italy*. Subject: *Tuning light-matter lasers of macroscopically coupled exciton polariton condensates.*

June, 2019: Seminar at Hybrid Polaritonics Programme Grant Meeting in University of Southampton, - *Southampton, UK*. Subject: *Giant vortices in polariton polygons.*

November, 2018: Seminar at University of Southampton, - *Southampton, UK*. Subject: *All-to-all intra-modal condensate coupling by multi-frequency excitation of polaritons.*

September, 2018: Seminar at University of Iceland, - *Reykjavik, Iceland*. Subject: *Lattices of exciton-polariton Bose-Einstein condensates.*

May, 2018: Contributed talk at the International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN19) - *Chengdu, China*. Subject: *Parity Competition in Exciton-Polariton Condensates, and Solving the Max-Eigenvalue Problem.*

March, 2018: Contributed talk at the International Conference on Terahertz Emission Metamaterials and Nanophotonics (TERAMETANANO-3) - *Yucatan, Mexico*. Subject: *Competition of parities in nonresonantly driven exciton-polariton condensates.*

January, 2018: Seminar at University of St. Andrews, - *St. Andrews, UK*. Subject: *Competition of the parities: Multistability, domain walls, defects, and bifurcations in polariton condensates.*

December, 2017: Seminar at Skolkovo Institute of Science and Technology, - *Moscow, Russia*. Subject: *Competition of the parities: Multistability, domain walls, defects, and bifurcations in polariton condensates.*

May, 2017: Contributed talk at the International Conference on Terahertz Emission Metamaterials and Nanophotonics (TERAMETANANO-2) - *Venice, Italy*. Subject: *A driven-dissipative spin chain model based on exciton-polariton condensates.*

May, 2017: Contributed talk at the Physics of Exciton-Polaritons in Artificial Lattices - *PCS IBS, Daejeon, South Korea*. Subject: *A driven-dissipative spin chain model based on exciton-polariton condensates.*

March, 2016: Contributed talk at the International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN17) - *Nara, Japan*. Subject: *Switching waves in multi-level incoherently driven polariton condensates.*

March, 2016: Contributed talk at the Institute of Physics Singapore (IPS) - *Singapore*. Subject: *Switching Waves in Multi-Level Incoherently Driven Polariton Condensates.*

October, 2015: Contributed talk at the International Conference on Optics of Excitons in Confined Systems (OECS) - *Jerusalem, Isreal*. Subject: *Information processing with topologically protected vortex memories in exciton-polariton condensates.*

August, 2015: Contributed talk at the International Conference on Metamaterials, Photonic Crystals and Plasmonics (META) - *New York, USA*. Subject: *Information processing with topologically protected vortex memories in exciton-polariton condensates.*

March, 2015: Contributed talk at the Institute of Physics Singapore (IPS) - *Singapore*. Subject: *Information processing with topologically protected vortex memories in exciton-polariton condensates.*

October, 2014: Seminar at Visindadagur in University of Iceland, - *Reykjavik, Iceland*. Subject: *Information processing with topologically protected vortex memories in exciton-polariton condensates.*

May, 2014: Contributed talk at the International Conference on Problems of Strongly Correlated and Interacting Systems (RQC) - *St. Petersburg, Russia*. Subject: *Vortices in spinor cold exciton condensates with spin-orbit interaction.*

February, 2014 Contributed talk at the Institute of Physics Singapore (IPS) - *Singapore*. Subject: *Vortices in spinor cold exciton condensates with spin-orbit interaction.*

Management of students and researchers

Students/staff supervised

- Mr. Valtýr Kári Daníelsson (PhD student, University of Iceland)
- Dr. Luciano Ricco (PostDoc, University of Iceland)
- Ms. Zuzanna Werner (BSc student, University of Warsaw)
- Mr. Andrzej Frączak (MSc student, University of Warsaw)
- Mr. Maciej Zaremba (MSc student, University of Warsaw)
- Mr. Eryk Imos (MSc student, University of Warsaw)

Co-supervision duties

List of students and junior researchers and their relevant research projects in the Hybrid Photonics group of Prof. Pavlos Lagoudakis under my co-supervision:

- Mr. Denis Aristov (MSc, Skolkovo Institute of Science and Technology, Graduated 2022) — Project 1, Project 2
- Mr. Ivan Krasionov (MSc, Skolkovo Institute of Science and Technology, Graduated 2023)
- Mr. Yuan Wang (PhD, University of Southampton, Graduated 2023) — Project 1; Project 2
- Mr. Ivan Gnusov (PhD, Skolkovo Institute of Science and Technology, Graduated 2023) — Project 1; Project 2; Project 3
- Dr. Stella Harrison (PhD, University of Southampton, Graduated 2022) — Project 1; Project 2; Project 3
- Mr. Pavel Kokhanchik (MSc, Skolkovo Institute of Science and Technology, Graduated 2021) — Project 1
- Mr. Joel Abraham (MSc, University of Southampton, Graduated 2021)
- Mr. Gethin Lewis (MSc, University of Southampton, Graduated 2021)

Teaching duties

(2015 - 2016) Assistant lecturer at Nanyang Technological University:
General Physics II (PH1802) — **1 semester - 100 hours** — Lecturer: Asst. Prof. Lan Shau-Yu
Undergraduate Experimental Physics (PH2199) — **1 semester - 100 hours** — Lecturer: Dr. Moo Aun Mee

(2010 - 2022) Assistant lecturer at University of Iceland:
General Physics I — **4 semesters - 400 hours** — Lecturer: Prof. Snorri Þorgeir Ingvarsson
General Physics II — **1 semester - 100 hours** — Lecturer: Prof. Einar Örn Sveinbjörnsson
Introduction to Quantum Mechanics — **3 semesters - 300 hours** — Lecturer: Prof. Lárus Thorlacius
Thermodynamics — **1 semester - 100 hours** — Lecturer: Dr. Pavel Bessarab
Undergraduate Experimental Physics — **4 semesters - 400 hours** — Lecturer: Assoc. Prof. Ari Ólafsson
Advanced Topics in Electrodynamics — **1 semesters - 100 hours** — Lecturer: Prof. Habib Rostami