Nikodem Szpak

Dr. phil. nat.

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Current position

Position	Postdoc
Office address	Fakultät für Physik, Universität Duisburg–Essen
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Education & Scientific Career

2017–   **Postdoctoral position**, *Faculty of Physics, University Duisburg–Essen*, Duisburg.

2014–2016   **Eigene Stelle (DFG)**, *Faculty of Physics, University Duisburg–Essen*, Duisburg.
Project: "Quantum simulators for relativistic quantum fields in curved spaces with defective optical lattices and graphenes"

2009–2013   **Postdoctoral position**, *Faculty of Physics, University Duisburg–Essen*, Duisburg.

2006–2009   **Postdoctoral position**, *Albert-Einstein-Institute (Max-Planck-Institute for Gravitational Physics)*, Golm/Potsdam.
Mathematical (Prof. Dr. G. Huisken) and Astrophysical (Prof. Dr. B. Schutz) Departments

2005 Feb–May   **Visitor**, *Albert-Einstein-Institute (Max-Planck-Institute for Gravitational Physics)*, Golm/Potsdam.
Department of Geometric Analysis, Supervision: Dr. Bernd G. Schmidt, Dr. Lars Andersson

2004   **Assistant**, *Frankfurt International Graduate School for Science (FIGSS), Goethe University*, Frankfurt am Main.

2001–2005   **PhD in Physics (Dr. rer. nat.)**, *Institute for Theoretical Physics, Goethe University*, Frankfurt am Main, Supervisor: Prof. Dr. Dr. hc. mult. Walter Greiner.
Thesis: "Spontaneous particle creation in time-dependent overcritical fields of Quantum Electrodynamics"

2000–2001   **Scholarship**, *Institute for Theoretical Physics, Goethe University*, Frankfurt/Main.

1995–1999   **M.Sc. in Physics**, *Institute of Physics, Jagellonian University*, Cracow, Poland, Supervisor: Prof. Piotr Bizon (Dep. of General Relativity and Astrophysics).
Thesis: "Relaxation to unstable attractors in nonlinear wave equations"

1996–1997   **EMSPS-TEMPUS scholarship**, *Institute for Physics, Goethe University*, Frankfurt am Main, (German "Vordiplom" (B.Sc) in Physics).

1993–1996   **B.Sc. in Computer Science**, *College for Computer Sciences and Management*, Bielsko-Biała, Poland, (parallel to the Secondary School).

Funds, Scholarships, Prizes & Awards

2014	**Grant** of the Andrejewski-Stiftung for organisation of the Workshop "Geometric Methods in Classical and Quantum Lattice Systems", Einsteinhaus, Caputh [7.500 Euro]
2014–2015	**DFG Grant (Eigene Stelle)** for the Project "Quantum simulators for relativistic quantum fields in curved spaces with defective optical lattices and graphenes", University Duisburg–Essen [155.000 + 15.500 Euro]
2012	**Junior Researcher Grant** of the University Duisburg–Essen [25.000 Euro]
2006–08	**Postdoctoral research grant** of the Max Planck Society
2005	**Visiting grant** of the Max Planck Society
2002–2003	**Scholarship** of Hessische Landesgraduiertenförderung
2001	**Award** of Deutsche Akademische Austauschdienst (DAAD) for highly qualified foreign students, University Frankfurt am Main
2000–2001	**Scholarship** of Deutsche Forschungsgemeinschaft (DFG), University Frankfurt am Main
1997, 98, 99	**Award** of the Minister of Education (Cracow)
1996	**Scientific award** at the Jagellonian Univ.
1996–1997	**EMSPS-Tempus Scholarship** (European Student Exchange Programme, Frankfurt am Main)

▬▬▬ Invitations and longer scientific stays

2014 Sept	Research stay at the Max-Planck-Institute for Gravitational Physics in Golm/Potsdam
2013 March	Research stay at the Max-Planck-Institute for Gravitational Physics in Golm/Potsdam
2012 Apr	Research stay at Institute of Physics, University Cracow
2011 June	Workshop on "Nonlinear Dispersive Equations", Eidgenössische Technische Hochschule Zürich ETH, Zürich
2011 Jan	Workshop on "Quantitative Studies of Nonlinear Wave Phenomena (follow-up)", Erwin- Schrödinger-Institut, Vienna
2010 Aug–Sept	Research stay at the Max-Planck-Institute for Gravitational Physics in Golm/Potsdam
2010 June	Workshop on "Mathematical Aspects of Quantum Electrodynamics", Insitute-Henri-Poincare, Paris
2010 Apr	Workshop on "Quantum Gravity QG10", Max-Planck-Institute for Physics of Complex Systems, Dresden
2010 Feb	Workshop on "Quantitative Studies of Nonlinear Wave Phenomena", Erwin-Schrödinger-Institut, Vienna
2009 Oct	Workshop on "Mathematical Aspects of General Relativity", Mathematisches Forschungsinstitut, Oberwolfach
2009 Mai–July	Workshop on "Nonlinear waves and dispersion", Institut Henri Poincare, Paris
2009 Apr	Research stay at Institute of Physics, University Cracow
2008 Sept	Workshop on "Geometry, Analysis, and General Relativity", Mittag-Leffler Institute, Stockholm
2008 June	Workshop on "Hyperbolic Equations in Relativity", Math. Inst. of Bordeaux
2008 April	Research stay at UC San Diego, California
2006 Dec	Research stay at University of Cergy-Pontoise, Paris

Teaching experience

2023   Course on "Methematical Methods in Quantum Mechanics" (for Energy Science), Univ. Duisburg-Essen

2022   Course on "Methematical Methods in Electrodynamics" (for Energy Science), Univ. Duisburg-Essen

2022   Lecture course (online due to Covid-19) on "General Relativity" (incl. exercise group), Univ. Duisburg-Essen

2021   Course on "Methematical Methods in Electrodynamics" (for Energy Science), Univ. Duisburg-Essen

2021   Lecture course (online due to Covid-19) on "Quantum Field Theory" (incl. exercise group), Univ. Duisburg-Essen

2020   Lecture course (online due to Covid-19) on "General Relativity" (incl. exercise group), Univ. Duisburg-Essen

2019   Course on "Methematical Methods in Electrodynamics" (for Energy Science), Univ. Duisburg-Essen

2018   Lecture course on "Quantum Field Theory" (incl. exercise group), Univ. Duisburg-Essen

2018   Lecture course on "General Relativity" (incl. exercise group), Univ. Duisburg-Essen

2017   Course on "Mathematical Methods in Electrodynamics" (for Energy Science), Univ. Duisburg-Essen

2016   Course on "Mathematical Methods in Quantum Mechanics" (for Energy Science), Univ. Duisburg-Essen

2015, 2016   Lecture course on "General Relativity" (incl. exercise group and projects), Univ. Duisburg-Essen

2013–2014   Exercises to courses in Theoretical Physics (incl. for Energy Science) at Univ. Duisburg-Essen

2012   Lecture course on "General Relativity" (incl. exercise group), Univ. Duisburg-Essen

2012   Lecture course on "Mathematical Methods of Classical Mechanics", Univ. Duisburg-Essen

2009–2012   Exercises to a series of courses in Theoretical Physics (incl. for physics teachers), Univ. Duisburg–Essen
- Theoretical Physics I & II,
- Quantum Field Theory,
- General Relativity,
- Classical Mechanics

2009–2010   Lecture course on "General Relativity" (incl. exercise group), Univ. Duisburg–Essen

2009   Lecture course on "Gravitational Field Theory" at Jürgen Ehlers Spring School "Gravitational Physics", Albert-Einstein-Institute, Golm/Potsdam

2007–2008   Seminar on "Wave Equations and Black Hole Stability", Albert-Einstein-Institute, Golm/Potsdam

2000-2004   Exercises to a series of courses in Theoretical Physics at Univ. Frankfurt am Main:
- Classical Mechanics I & II (incl. Special Relativity),
- Electrodynamics,
- Quantum Mechanics,
- Thermodynamics and Statistical Physics,
- Analysis I

1998   Seminar "Understanding partial differential equations", Univ. Cracow

Supervision

2022-2023   Master Thesis "Continuum Theory of Lattice Defects and Deformations Modeled by Curvature and Torsion", Enkeleta Berisha, Univ. Duisburg-Essen

2022   Exchange student, Santiago Galvan y Garcia, UNAM, Mexico (Dr. T. Stegmann), "Project: Periodic Kekule deformations of graphene"

2021-2022   Master Thesis "Nichtgleichgewichtsdynamik in Quantenpunktsystemen: Beschreibung durch zeitabhängige Lindblad-Operatoren", Lukas Litzba, Univ. Duisburg-Essen

2021   Exchange student, Jesus Arturo Sanchez, UNAM, Mexico (Dr. T. Stegmann), "Project: Relaxation of atomic structures in elastically deformed graphene"

2019-2020   Master Thesis "Streuung an Defekten in Graphen", Ozan Günes, Univ. Duisburg-Essen

2019-2020   Master Thesis "Interaction Effects in Quantum Simulations of Spontaneous Pair Creation", Jan Verlage, Univ. Duisburg-Essen

2019   Exchange student, Emmanuel Peredes, UNAM, Mexico (Dr. T. Stegmann), "Project: Electron optics in graphene NP junctions"

2018   Bachelor Thesis "Optische Skalare und Fokussierung im deformierten Graphen", Haris Colic, Univ. Duisburg-Essen

2017-2018   Master Thesis "Quantensimulation von spontanner Paarerzeugung in optischen Gittern", Leonhard Klar, Univ. Duisburg-Essen

2016   Bachelor Thesis "Elektronischer Transport in gekrümmten und deformierten Graphen-Nanoröhrchen", Eric Kleinherbers, Univ. Duisburg-Essen

2015   Projekte für Studenten des Studiengangs Energy Science, Univ. Duisburg-Essen:
   - "Bandlücke in Graphen-Nanoröhrchen mit parallelem Magnetfeld", Lennart Korsten
   - "Magnetischer Feld-Effekt Transistor in Graphen-Nanoröhrchen", Magdulin Dwedari
   - "Stromflußwege in gekrümmten Graphen-Nanoröhrchen", Eric Kleinherbers

2015   Bachelor Thesis "Propagation von Gravitationswellen im expandierenden Universum", Marco Orts, Univ. Duisburg-Essen

2014 – 2015   Master Thesis "Resonante nichtlineare Modenkopplung als Mechanismus der Instabilität des AdS (anti-de Sitter) Universums", Konstantin Obrubov, Univ. Duisburg-Essen

2012   Bachelor Thesis "Pulse shape dependence of the dynamically assisted Sauter-Schwinger effect", Joachim Sicking, Univ. Duisburg-Essen (co-supervision with Prof. Ralf Schützhold

Publications

QED, optical lattices, quantum dots, graphene, analog gauge fields and gravity

2023   **J. Verlage, F. Queisser, N. Szpak, J. König, P. Kratzer and R. Schützhold**, *Quasi-particle propagation across semiconductor-Mott insulator interfaces*, submitted, arXiv:2303.13507, [9 pages].

2023   **E. Kleinherbers, T. Stegmann and N. Szpak**, *Electronic transport in bent carbon nanotubes*, Phys. Rev. B 107, 195424 (2023), arXiv:2302.01395, [13 pages].

2022   **G. Schaller, F. Queisser, N. Szpak, J. König and R. Schützhold**, *Environment-induced decay dynamics of anti-ferromagnetic order in Mott-Hubbard systems*, Phys. Rev. B 105, 115139 (2022), arXiv:2112.04956, [15 pages].

2022   **W. Ortiz, N. Szpak and T. Stegmann**, *Graphene nanoelectromechanical systems as valleytronic devices*, Phys. Rev. B 106, 035416 (2022), arXiv:2202.01739, [11 pages].

2021 **E. Paredes-Rocha, Y. Betancur-Ocampo, N. Szpak and T. Stegmann**, *Gradient-index electron optics in graphene pn junctions*, Phys. Rev. B 103, 045404 (2021), arXiv:2009.05535, [11 pages].

2020 **E. Kleinherbers, N. Szpak, J. König and R. Schützhold**, *Relaxation dynamics in a Hubbard dimer coupled to fermionic baths: phenomenological description and its microscopic foundation*, Phys. Rev. B 101, 125131 (2020), arXiv:1910.04130, [17 pages].

2019 **L. Klar, N. Szpak, R. Schützhold**, *Quantum simulation of spontaneous pair creation in 2D optical lattices*, arXiv:1901.09880, [5 pages].

2019 **N. Szpak and R. Schützhold**, *Time reversal and quantum Loschmidt echo in optical lattices*, arXiv:1901.05941, [5 pages].

2018 **T. Stegmann and N. Szpak**, *Current splitting and valley polarization in elastically deformed graphene*, 2D Materials 6 (2019) 015024, arXiv:1806.09576, [8 pages].

2016 **T. Stegmann and N. Szpak**, *Current flow paths in deformed graphene: from quantum transport to classical trajectories in curved space*, New J. Phys. 18 (2016) 053016, hep-th/1512.06750, [15 pages] [OA].

2015 **M. F. Linder, C. Schneider, J. Sicking, N. Szpak and R. Schützhold**, *Pulse shape dependence in the dynamically assisted Sauter-Schwinger effect*, Phys. Rev. D92, 085009 (2015), hep-th/1505.05685, [13 pages].

2014 **N. Szpak**, *Curved spacetimes in the lab*, arXiv:1410.1567, [9 pages].

2014 **N. Szpak**, *A sheet of graphene - quantum field in a discrete curved space*, 100 Years after Einstein in Prague, Series: Springer Proceedings in Physics, Vol. 157 (2014), Bicák, Jirí, Ledvinka, Tomáš (Eds.), [8 pages].

2012 **N. Szpak and R. Schützhold**, *Optical lattice quantum simulator for QED in strong external fields: spontaneous pair creation and the Sauter-Schwinger effect*, New J. Phys. 14, 035001 (2012), quant-ph/1109.2426, [24 pages] [OA].

2011 **N. Szpak and R. Schützhold**, *Quantum simulator for the Schwinger effect with atoms in bi-chromatic optical lattices*, Phys. Rev. A 84, 050101(R) (2011), quant-ph/1103.0541, [4 pages].

2008 **N. Szpak**, *Spontaneous particle creation in time-dependent overcritical fields*, J. Phys. A: Math. Theor. 41 (2008) 164059 (7pp), hep-th/0604101, [7 pages].

2007 **N. Szpak**, *Spontaneous particle creation within the external field approximation of QED*, Proc. Appl. Math. Mech. 7, 1141401-1141402 (2007), [2 pages].

2005 **P. Marecki and N. Szpak**, *Spontaneous emission of light from atoms: the model*, Ann. d. Phys. 14, 428-437 (2005), quant-ph/0407186, [10 pages].

2003 **N. Szpak**, *'Spontaneous pair creation' in strong electric fields of Highly Charged Ions*, NIMB, Vol: 205, May, 2003, pp: 30-35, [6 pages].

General Relativity and the theory of PDEs

2011 **P. Bizon, T. Chmaj and N. Szpak**, *Dynamics near the threshold for blowup in the one-dimensional focusing nonlinear Klein-Gordon equation*, J. Math. Phys. 52, 103703 (2011), math.AP/1012.1033, [11 pages].

2011 **R. Bieli and N. Szpak**, *Global pointwise decay estimates for defocusing radial nonlinear wave equations*, Comm. PDE, 36 (2), pp. 205-215 (Feb. 2011), math.AP/0903.0799, Institut Mittag-Leffler preprint, [11 pages].

2010 **N. Szpak**, *Asymptotics from scaling for nonlinear wave equations*, Comm. PDE, 35 (10), pp. 1876-1890 (Oct. 2010), math-ph/0907.4287, [15 pages].

2010 **R. Bieli and N. Szpak**, *Large data pointwise decay for defocusing semilinear wave equations*, arXiv: 1002.3623, [9 pages].

2010 **N. Szpak**, *Late-time attractor for the cubic nonlinear wave equation*, J. Math. Phys. 51, 082901 (2010), [4 pages].

2009 **N. Szpak**, *Comment on "Late-time tails of a self-gravitating scalar field revisited" by Bizon et al: The leading order asymptotics*, Class. Quantum Grav. 26 (2009) 248001, [7 pages].

2009 **N. Szpak, P. Bizon, T. Chmaj and A. Rostworowski**, *Linear and nonlinear tails II: exact decay rates in spherical symmetry*, Journal of Hyberbolic Differential Equations (JHDE), Vol. 6 (No. 1), pp. 107-125 (Mar. 2009), [19 pages].

2008 **N. Szpak**, *Linear and nonlinear tails I: general results and perturbation theory*, Journal of Hyberbolic Differential Equations (JHDE), Vol. 5, 741-765 (2008), math-ph/0710.1782, [25 pages].

2007 **N. Szpak**, *Simple proof of a useful pointwise estimate for the wave equation*, arXiv: math-ph/0708.2801, [7 pages].

2007 **N. Szpak**, *Weighted–L^∞ and pointwise space-time decay estimates for wave equations with potentials and initial data of low regularity*, arXiv: math-ph/0708.1185, [31 pages].

2004 **N. Szpak**, *Quasinormal mode expansion and the exact solution of the Cauchy problem for wave equations*, arXiv: gr-qc/0411050, [15 pages].

2001 **N. Szpak**, *Relaxation to unstable attractors in nonlinear wave equations*, Theoretical and Mathematical Physics, Vol. 127, No. 3, pp. 817-826, 2001, [10 pages].

Miscellaneous

Physical skills

GR	Einstein equations; Gravitational waves; Quasinormal modes of Black Holes; Relaxation in open systems; Spontaneous emission in atoms
QFT	QED in external fields; Spontaneous pair creation in strong fields; Vacuum instability
Analog models	Analog Schwinger effect (QED) in 1D optical lattice; Analog Gravity in perturbed 2D optical lattices and deformed graphene
Effective models	Electric current flow optimization in curved graphene nanoribbons and nanotubes, valleytronics, nanoelectronics
Referee for	Class. Quant. Grav., Phys. Rev. Lett. & D, J. Phys. A, Int. J. of Mod. Phys. E

Mathematical skills

Rigorous	Precise asymptotics for linear and nonlinear wave equations (PDE, convergence in weighted functional spaces); Eigenvalue problems (ODE), Operator algebra and representation theory in Hilbert spaces
Approximative	Decay estimates for linear and nonlinear waves equations (PDE, estimates in weighted functional spaces); Continuous elasticity theory for solid state and optical lattice systems; Geometrical optics for current flows
Numerical	Evolution of PDEs; Eigenvalue problems in ODEs; Complex analytic structure; Scattering theory & Bogoliubov transformations
Symbolic	Self–similar critical collapse in GR

Computer & programming skills

Scientific	Mathematica, Maple
Languages	C++, Pascal, Fortran, Basic, Assembler, Prolog, RNPL, MQL
OS	Linux (Server), Microsoft Windows
Other	LaTeX, HTML, OpenOffice / Microsoft Office, GNUplot

Other skills

- Financial markets (modeling and trading)
- Electronics (analog and digital)

Languages

Polish	Mothertongue	
German	Excellent	*written and spoken, teaching level*
English	Very good	*scientific written and spoken, oral presentations*

Interests

- Modeling of Nature (dynamical and stochastic processes)
- Brain (modeling of cognitive and learning processes)
- Psychology
- Religions

Hobbies & Sports

- Chess
- Football, Tennis, Judo
- Bike
- Sailing