Curriculum vitae

See `https://www.uni-muenster.de/Physik.TP/~wittkowski/cv.pdf` for an update.

Summary

Raphael Wittkowski is Assistant Professor for the "Theory of Active Soft Matter" at the Institute of Theoretical Physics of the University of Münster. Since age 23, he holds a B.Sc. degree in mathematics and B.Sc., M.Sc., and Dr. degrees in physics. He leads a working group at the Center for Soft Nanoscience and investigates active matter systems to reveal their fundamental properties and establish important practical applications. His research has a particular focus on sound-propelled microparticles and their relevance for medicine and materials science. He also deals with Statistical Physics, which he applies to a wide range of fields within and outside of physics. His methodological focus is on modeling incl. method development and computer simulations incl. software development. His research resulted in the discovery of several new effects and materials properties of active matter, invention of refractive light-propelled microparticles, derivation of some of the most important models of active matter physics, further development of important methods of statistical physics, and development of new scientific software such as `AcoDyn` for orders of magnitude faster acoustofluidic simulations. He has revealed many fundamental properties of sound-propelled microparticles and developed a medically relevant method for guiding such particles collectively to a target. He is internationally recognized for his contributions to the theory of active matter and statistical physics and widely seen as a leading scientist in computer simulations of sound-propelled microparticles. His 85 publications include 1 book, 7 review articles, 59 regular articles, 1 patent application, and 7 software packages. 17 articles were published in high-impact journals such as *Nat. Commun.* and *Sci. Adv.* Three of his review articles (2× *Adv. Phys.*) are widely seen as standard texts in the respective fields. 9 publications were selected as editors' highlight and 11 publications resulted in large press coverage. His publications have been cited 4085 times, 10 publications reached more than 100 citations each, his h-index is 29, and his i10-index is 49. He received several awards and fellowships, including a Heisenberg grant and an Emmy Noether grant of the German Research Foundation as well as a membership in the Junges Kolleg of the North Rhine-Westphalian Academy of Sciences, Humanities and the Arts, and was honored as "Emerging Leader" by the *J. Phys. Condens. Matter*.

General data

Name:	Prof. Dr. Raphael Wittkowski
Date of birth:	May 1988
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Google Scholar:	`https://scholar.google.de/citations?user=ZYxh1t0AAAAJ`

UoM = University of Münster, Germany

School and academic education

27/03/2012:	Dr. rer. nat. in physics ("summa cum laude"); supervisor: Prof. Dr. Hartmut Löwen; field: soft matter physics
10/2010-03/2012:	Doctoral studies in physics, HHU
29/09/2010:	M. Sc. in physics (grade 1.0, "with honors"); supervisor: Prof. Dr. Hartmut Löwen; field: soft matter physics
10/2009-09/2010:	Master degree course in physics, HHU
25/09/2009:	B. Sc. in physics (grade 1.1, "with honors"); supervisor: Prof. Dr. Karl-Heinz Spatschek; field: plasma physics
10/2006-09/2009:	Bachelor degree course in physics, HHU
29/07/2009:	B. Sc. in mathematics (grade 1.2, "with honors"); supervisor: Prof. Dr. Marlis Hochbruck; field: applied mathematics
10/2006-07/2009:	Bachelor degree course in mathematics, HHU

17/06/2006: Abitur (grade 1.1, "very good")
08/1998-06/2006: Heinrich-Heine-Gymnasium, Mettmann, Germany

HHU = Heinrich-Heine-Universität Düsseldorf, Germany

Professional career

04/2017-today: Independent[1] Assistant Professor (W1) for "Theory of Active Soft Matter", Institute of Theoretical Physics, UoM
10/2016-today: Independent[1] Emmy Noether research group leader, Institute of Theoretical Physics, UoM
01/2015-09/2016: Postdoctoral research fellow, Institute for Theoretical Physics II, HHU; host: Prof. Dr. Hartmut Löwen
01/2013-12/2014: Postdoctoral research fellow, School of Physics and Astronomy, University of Edinburgh, United Kingdom; host: Prof. Dr. Michael E. Cates (now: Lucasian Professor, University of Cambridge, UK)
04/2012-12/2012: Postdoctoral research associate, Institute for Theoretical Physics II, HHU; host: Prof. Dr. Hartmut Löwen
10/2010-03/2012: Research associate, Institute for Theoretical Physics II, HHU; host: Prof. Dr. Hartmut Löwen

[1]Independent = Not subject to another professorship, full self-responsibility

Awards, Fellowships, and Academy Memberships

X/202X-X/20XX: Heisenberg research grant, DFG
[German analogue of ERC Consolidator Grant]
29/04/2021: 3rd place on final candidates list, Full Professor (W3, chair) for "Statistical Physics", University of Augsburg, Germany
01/05/2019: Honored as "Emerging Leader" (identified as one of "the best early-career researchers from all areas of condensed matter physics [...] with the potential to revolutionise their fields") by the editorial board of the *Journal of Physics: Condensed Matter*
01/2019-12/2023: Membership in the Junges Kolleg of the North Rhine-Westphalian Academy of Sciences, Humanities and the Arts and accompanying research fellowship
10/2016-03/2024: Emmy Noether research grant, DFG
[German analogue of ERC Starting Grant]
01/2015-06/2015: Return fellowship, DFG
01/2013-12/2014: Postdoctoral research fellowship, DFG
30/01/2013: Dissertation award "Best dissertation in the Faculty of Mathematics and Natural Sciences of the year 2012" of the HHU
06/2008-07/2008: Travel grant, Wilhelm and Else Heraeus Foundation; Participation in the 58th Lindau Nobel Laureate Meeting (Physics) in Lindau, Germany
10/2006-09/2011: Study scholarship of the Studienstiftung des deutschen Volkes
17/06/2006: Book award of the Deutsche Physikalische Gesellschaft

DFG = Deutsche Forschungsgemeinschaft (German Research Foundation)

Grants

7 grants (4× ongoing, 3× completed), 3 funders, 2471 k€ funding (own share)
See *https://www.uni-muenster.de/Physik.TP/~wittkowski/grants.pdf.*

Selected grant:

• Project B01 in CRC 1459 "Intelligent matter", DFG (Co-PI, 01/2021-12/2024)

Teaching

53 courses in total (16 lecture courses [8/6/2 Bachelor/Master/Other], 37 seminars [7/15/15 Bachelor/Master/Other])
See https://www.uni-muenster.de/Physik.TP/~wittkowski/courses.pdf.

Supervision and career-advancement of young researchers

• 9 currently supervised persons (0/2/3/4 postdocs/doctoral candidates/Master students/Bachelor students)
• 31 formerly supervised postdocs and theses (1 postdoc, 6/12/12 doctoral/Master's/Bachelor's theses)
See https://www.uni-muenster.de/Physik.TP/~wittkowski/supervision.pdf.

• 22 successes achieved by supervised persons (6 awards; 2 scholarships; 3/11 publications resulted from Bachelor's/Master's theses)
See https://www.uni-muenster.de/Physik.TP/~wittkowski/successes.pdf.

Selected successes:

• A former Master's student and doctoral researcher reached the 1st place on the final candidates list for a W1 Tenure Track professorship at a German university in less than 1 year after defending his thesis.
• Walter Benjamin fellowship • Infineon Dissertation Award • Infineon Master Award

Institutional responsibilities

10 commitments in academic self-government in total
See https://www.uni-muenster.de/Physik.TP/~wittkowski/administration.pdf.

Refereeing activities

Funding agencies:	German Research Foundation (DFG), Alexander von Humboldt Foundation (AvH), Dutch Research Council (NWO),...
Journals:	Nature, Nature Physics, Nature Communications, New Journal of Physics, Journal of Chemical Physics, Physical Review Letters,...

Active memberships

2023-today:	Interdisciplinary Center for Mathematical Modeling of Infectious Disease Dynamics (founding member)
2023-today:	Deutscher Hochschulverband
2021-today:	Wigner Initiative
2018-today:	Center for Soft Nanoscience
2016-today:	Center for Nonlinear Science
2006-today:	Deutsche Physikalische Gesellschaft

Research

a) Fields

The research focuses on the theory of **active matter** and **statistical physics**, but addresses also a wide range of other fields within and outside of physics.
• His current main topic is **sound-propelled microparticles (microrobots)** and their potential applications in medicine and materials science. These are particles that can move, similar to remote-controlled micro-submarines, in liquids and biological tissue and have great potential for practical applications. For example, he considers medical applications, such as targeted drug delivery and microinvasive surgery, as well as active materials based on these particles and their special properties that are not observed in other materials. This topic is strongly

related to ultrasound, fluid dynamics, acoustofluidics, microrobotics, nanomedicine, and programmable/intelligent matter.
• He is a **leading researcher in this field** and internationally respected especially for the computer simulation of sound-propelled microparticles. For these particles, his group carried out the most complex computer simulations, developed probably the most powerful simulation software, and published the most comprehensive simulation-based articles.

b) Methods

He applies various methods of theoretical and computational physics, where his focus is on analytical modeling incl. method development and computer simulations incl. software development, i.e., modeling and simulation of materials and other many-particle systems.
• As part of the methodological focus **analytical modeling incl. method development**, he applies methods of statistical physics to model materials and other many-particle systems. The main task is to systematically and predictively derive a model for materials/systems for which no model equations are yet known. While, e.g., a model (the Navier-Stokes equations) is already known to describe the dynamics of simple fluids, such a model is missing for most materials/systems. His methods can now be applied to almost all materials/many-particle systems (partly because he was involved in the further development of several methods). In his group, these methods have already been applied to, e.g., quantum systems, many classical systems such as soft matter, active materials, biological systems, and the spread of epidemics in populations, as well as in plasma physics and cosmology, and have led to publications in these very different fields.
• As part of the methodological focus **computer simulations incl. software development**, he carries out field-based simulations (esp. using the finite volume method) and particle-based simulations (esp. molecular dynamics simulations). His group has also developed several software packages. These include AcoDyn based on the finite volume method for particularly complex and fast fluid dynamic and acoustofluidic simulations and FIPS for molecular dynamics simulations with advantages over other software such as LAMMPS.
See `https://www.uni-muenster.de/Physik.TP/~wittkowski/research.pdf`.

Selected scientific achievements

1. **Discovery of several new effects and materials properties in active matter**. Examples: *Shape-induced gravitaxis* [Nat. Commun. **5**, 4829 (2014)], *Programmable self-organization* [Sci. Adv. **2**, e1501850 (2016), Phys. Rev. Lett. **131**, 168203 (2023)], *Anomalous sound modes* [New J. Phys. **23**, 063023 (2021)], *Active tunnel effect* [Nat. Commun. **14**, 1302 (2023)]
2. **Further development of several important methods of statistical physics** and **publication of frequently cited review articles** on each of these methods: *Classical dynamical density functional theory* [**Reviews:** Adv. Phys. **69**, 121-247 (2020)*, J. Phys. Condens. Matter **35**, 041501 (2023)], *Interaction-expansion method* [**Review:** J. Phys. Condens. Matter **35**, 313001 (2023)]*, *Mori-Zwanzig projection operator formalism* [**Review:** Eur. J. Phys. **41**, 045101 (2020)], *Phase-field-crystal models* [**Review:** Adv. Phys. **61**, 665-743 (2012)]*. Three of these review articles (marked by *) are widely seen as the **standard texts on the respective methods**.
3. **Derivation of a large number of new models**. Examples: *Active Model B* [Nat. Commun. **5**, 4351 (2014)], *Active Model H* [Phys. Rev. Lett. **115**, 188302 (2015)], *Active Models I and I+* [Nat. Commun. **14**, 1302 (2023)], *SIR-DDFT model* [Nat. Commun. **11**, 5576 (2020)]. The active models belong to the **most important models of active matter physics** and the last model, describing the spread of infectious diseases, received **much attention in physics and medicine**.

4. **Development of several scientific software packages** with advantages compared to other existing software, such as **AcoDyn** for orders of magnitude faster acoustofluidic simulations and **FIPS** for safer and more flexible molecular dynamics simulations.
5. **Invention of refractive light-propelled microparticles** [J. Phys. Photonics **5**, 022501 (2023), section 30].
6. **Investigation of the orientation-dependent propulsion of anisotropic microparticles that are exposed to a traveling ultrasound wave** and demonstration that they can move lateral, parallel, and even antiparallel to the sound wave and are therefore **relevant for a number of medical applications** [ACS Nano **16**, 3604-3612 (2022)].
7. **Development of a medically relevant method for guiding acoustically propelled microparticles collectively to a target** [Nanoscale Adv. **4**, 2844-2856 (2022)].

See ***https://www.uni-muenster.de/Physik.TP/~wittkowski/research.pdf.***

Cooperations

65 cooperators (23× experiment, 42× theory), 12 countries, 11 fields
See ***https://www.uni-muenster.de/Physik.TP/~wittkowski/cooperations.pdf.***

Talks

113 talks and presentations in total (28× invited, 85× contributed)
See ***https://www.uni-muenster.de/Physik.TP/~wittkowski/talks.pdf.***

Publications

• 85 publications in total (1× book, 7× review article, 59× regular article, 1× conference proceeding, 8× preprint, 1× patent application, 7× software, 1× other)
• including 17 high-impact-journal articles, 11 publications that resulted in press reports, 9 publications selected as highlight by the editor, 8 invited publications
• 4085 citations in total, 1/6/10/49 publications with more than 400/200/100/10 citations
• h-index 29, i10-index 49
See ***https://www.uni-muenster.de/Physik.TP/~wittkowski/publications.pdf.***

a) Ten selected peer-reviewed articles

[1] M. te Vrugt, H. Löwen, and R. Wittkowski,
Classical dynamical density functional theory: from fundamentals to applications,
Advances in Physics **69**, 121–247 (2020). DOI: 10.1080/00018732.2020.1854965.
Press reports: 7thSpace, Bioengineer, Brinkwire, EurekAlert!, Informationsdienst Wissenschaft, Infosurhoy, Phys.org, Science Bulletin, ScienceDaily, Sciencesprings, Scienmag, University of Düsseldorf, University of Münster.

[2] M. te Vrugt, J. Bickmann, and R. Wittkowski,
Effects of social distancing and isolation on epidemic spreading modeled via dynamical density functional theory,
Nature Communications **11**, 5576 (2020). DOI: 10.1038/s41467-020-19024-0.
Featured article. Selected as Editors' Highlight for the Focus "Applied physics and mathematics". Selected for a Focus in Physik Journal **20**, 6, 18-19 (2021). Press reports: Abitur und Studium, Analytik News, Archytele, Avalanches, Bioengineer, Bioon, Bocholter-Borkener Volksblatt, DE24 News, Deutsches Ärzteblatt, Dorstener Zeitung, EurekAlert!, Healthcare Hygiene Magazine, Heilpraxisnet, Informationsdienst Wissenschaft, JuraForum, Laborpraxis, Medical Xpress, Münsterland-Zeitung, myScience, Nachedeu, NewsBeezer, NotiUlti, Osel, Pediatric Radiology, Research in Germany, Ruhr-Nachrichten, ScienceDaily, Scienmag,

Stadt4.0, Tekk.tv, TheDietWorld, TodayHeadline, University of Münster, Wemp, Westfälische Nachrichten, wissen|leben, Wissen.Newzs.

[3] M. te Vrugt, T. Frohoff-Hülsmann, E. Heifetz, U. Thiele, and R. Wittkowski, *From a microscopic inertial active matter model to the Schrödinger equation*, Nature Communications **14**, 1302 (2023). DOI: 10.1038/s41467-022-35635-1. Featured article. Selected as Editors' Highlight for the Focus "Applied physics and mathematics". Press reports: AZoNano, EurekAlert!, Informationsdienst Wissenschaft, Innovations-Report, Nanowerk, Phys.org, Scienmag, University of Münster.

[4] R. Wittkowski, A. Tiribocchi, J. Stenhammar, R. J. Allen, D. Marenduzzo, and M. E. Cates, *Scalar ϕ^4 field theory for active-particle phase separation*, Nature Communications **5**, 4351 (2014). DOI: 10.1038/ncomms5351.

[5] B. ten Hagen, F. Kümmel, R. Wittkowski, D. Takagi, H. Löwen, and C. Bechinger, *Gravitaxis of asymmetric self-propelled colloidal particles*, Nature Communications **5**, 4829 (2014). DOI: 10.1038/ncomms5829. Selected for a Focus in Physik Journal **13**, 10, 21-23 (2014). Press reports: DRadio Wissen, Innovations-Report, LABO, Max Planck Society, Phys.org, University of Düsseldorf, University of Stuttgart, VBIO.

[6] Y. Deng, A. Paskert, Z. Zhang, R. Wittkowski, and D. Ahmed, *An acoustically controlled helical microrobot*, Science Advances **9**, eadh526 (2023). DOI: 10.1126/sciadv.adh5260. Featured article. Press reports: Cikavosti, Germanic.news, heise online, News Azi, Tech Xplore, Today Headline.

[7] J. Stenhammar, R. Wittkowski, D. Marenduzzo, and M. E. Cates, *Light-induced self-assembly of active rectification devices*, Science Advances **2**, e1501850 (2016). DOI: 10.1126/sciadv.1501850. Selected as Research Highlight in Nature Physics **12**, 376 (2016). Press reports: Big News Network, Business Standard, Dagens Nyheter, Daijiworld, DesignNews, ECN, EurekAlert!, FARS News, Forskning.se, Lund University, Nanotechnology Now, Newkerala, Noodls, Nvs24, ScienceDaily, Space Daily, University of Düsseldorf, Zee News.

[8] S. Raghuraman, A.-S. Schubert, S. Bröker, A. Jurado, A. Müller, M. Brandt, B. E. Vos, A. D. Hofemeier, F. Abbasi, M. Stehling, R. Wittkowski, J. Ivaska, and T. Betz, *Pressure drives rapid burst-like coordinated cellular motion from 3D cancer aggregates*, Advanced Science **9**, 2104808 (2022). DOI: 10.1002/advs.202104808.

[9] J. Voß and R. Wittkowski, *Orientation-dependent propulsion of triangular nano- and microparticles by a traveling ultrasound wave*, ACS Nano **16**, 3604–3612 (2022). DOI: 10.1021/acsnano.1c02302. Press reports: AZoNano, Bionity, ChemEurope, c't, EurekAlert!, Informationsdienst Wissenschaft, Innovations-Report, Mirage.News, Nanowerk, Phys.org, Pro-Physik.de, ScienceDaily, Scienmag, University of Münster.

[10] M. te Vrugt, S. Hossenfelder, and R. Wittkowski, *Mori-Zwanzig formalism for general relativity: a new approach to the averaging problem*, Physical Review Letters **127**, 231101 (2021). DOI: 10.1103/PhysRevLett.127.231101.

Press reports: Borkener Zeitung, EurekAlert!, Frankfurt Institute for Advanced Studies, Informationsdienst Wissenschaft, Innovations-Report, Münsterland Zeitung, N+1, Phys.org, Popmech, Pro-Physik.de, Sciencesprings, SciTechDaily, Space Daily, Tech Explorist, University of Münster.

b) Patent application

[1] R. Wittkowski [inventor], University of Münster [applicant],
Vorrichtung und Verfahren zum Sortieren von Partikeln mittels Strahlung.
German Patent and Trade Mark Office, patent pending, 2019.