Karol Makuch
Institute of Chemical Physics
Polish Academy of Sciences

Warsaw, November 27, 2024

CURRICULUM VITAE

PERSONAL INFORMATION

Date and place of birth	1981, Poland
Nationality	Polish
Correspondence address	Poland
Phone number	
E-mail	kmakuch@ichf.edu.pl
Personal website	http://www.karolmakuch.com
ORCID	0000-0002-9769-7646
Web of Science ResearcherID	AAS-1769-2021
Scopus ID	55505546900

EMPLOYMENT

- Institute of Physical Chemistry of Polish Academy of Sciences (since 2015), assistant professor (Polish: adiunkt)

EDUCATION

- 2005 – 2011: Ph.D. studies, Faculty of Physics, University of Warsaw, thesis titled „Hydrodynamic function and transport coefficients for suspensions of spherical particles" supervised by prof. dr hab. Bogdan Cichocki
- 2000 – 2005: master studies in Physics in the field of theoretical physics, Faculty of Physics, University of Warsaw, master thesis titled „Effective propagator for systems with induced sources of interparticle interactions" supervised by prof. dr hab. Bogdan Cichocki

SCIENTIFIC EXPERIENCE

- since 01.12.2015: assistance professor at the Institute of Physical Chemistry of Polish Academy of Sciences, Warsaw
- 03.2019 – 03.2020 postdoc at the California Institute of Technology (work with Dr. John Brady funded by the Polsih National Agance for Academic Exchange)
- 01.01.2017 - 30.04.2017: postdoc at the California Institute of Technology (work with Dr. John Brady funded by the Kosciuszko Foundation)
- 10.06.2013 - 09.12.2016: grant holder, Faculty of Physics, University of Warsaw
- 01.10.2011 - 30.06.2015: postdoctoral position in TEAM project (project leader: dr hab., Krzysztof Byczuk, prof. of University of Warsaw), Faculty of Physics, University of Warsaw

LIST OF SCIENTIFIC PUBLICATIONS

1. Karol Makuch
   "Tailoring the first law of thermodynamics for convective flows"
   Physics of Fluids 36, 111701 (2024) https://doi.org/10.1063/5.0239207
2. Robert Hołyst, Paweł J Żuk, Anna Maciołek, Karol Makuch, Konrad Giżyński

"Direction of spontaneous processes in non-equilibrium systems with movable/permeable internal walls"
Entropy 2024, 26, 713. DOI:10.3390/e26080713

3. Karol Makuch, Robert Hołyst, Konrad Giżyński, Anna Maciołek and Paweł J. Żuk
"Steady-state thermodynamics of a system with heat and mass flow coupling"
J. Chem. Phys. 159, 194113 (2023) DOI:10.1063/5.0170079
4. Robert Hołyst, Paweł J. Żuk, Karol Makuch, Anna Maciołek and Konrad Giżyński
"Fundamental Relation for the Ideal Gas in the Gravitational Field and Heat Flow"
Entropy 2023, 25, 1483. DOI:10.3390/e25111483
5. Anna Maciołek, Robert Hołyst, Karol Makuch, Konrad Giżyński and Paweł J. Żuk
"Parameters of State in the Global Thermodynamics of Binary Ideal Gas Mixtures in a Stationary Heat Flow"
Entropy 2023, 25, 1505. DOI:10.3390/e25111505
6. Robert Hołyst, Karol Makuch, Konrad Giżyński, Anna Maciołek and Paweł J. Żuk
"Fundamental Relation for Gas of Interacting Particles in a Heat Flow"
Entropy 2023, 25, 1295. DOI:10.3390/e25091295
7. Robert Hołyst, Karol Makuch, Anna Maciołek and Paweł J. Żuk "Thermodynamics of stationary states of the ideal gas in a heat flow"
J. Chem. Phys. 157, 194108 (2022), DOI:10.1063/5.0128074
8. Pacocha, Natalia and Zapotoczna, Marta and Makuch, Karol and Bogusławski, Jakub and Garstecki, Piotr
"You will know by its tail: a method for quantification of heterogeneity of bacterial populations using single-cell MIC profiling" Lab Chip, 2022, 22, 4317-4326, DOI:10.1039/D2LC00234E
9. Paweł J. Żuk, Karol Makuch, Robert Hołyst and Anna Maciołek
"Transient dynamics in the outflow of energy from a system in a nonequilibrium stationary state"
Phys. Rev. E 105, 054133 (2022), DOI:10.1103/PhysRevE.105.054133
10. Giżynski, Konrad and Makuch, Karol and Paczesny, Jan and Zhang, Yirui and Maciołek, Anna and Hołyst, Robert
"Internal energy in compressible Poiseuille flow"
Phys. Rev. E 104, 055107 (2021), DOI:10.1103/PhysRevE.104.055107
11. Yirui Zhang, Marek Litniewski, Karol Makuch, Paweł J. Żuk, Anna Maciołek, and Robert Hołyst
"Continuous nonequilibrium transition driven by heat flow"
Phys. Rev. E 104, 024102 (2021), DOI: 10.1103/PhysRevE.104.024102
12. Natalia Pacocha, Jakub Bogusławski, Michał Horka, Karol Makuch, Kamil Liżewski, Maciej Wojtkowski, and Piotr Garstecki
"High-Throughput Monitoring of Bacterial Cell Density in Nanoliter Droplets: Label-Free Detection of Unmodified Gram-Positive and Gram-Negative Bacteria"
Anal. Chem. 2021, 93, 2, 843–850
13. Adam S. Opalski, Karol Makuch, Ladislav Derzsi and Piotr Garstecki
"Split or slip - passive generation of monodisperse double emulsions with cores of varying viscosity in microfluidic tandem step emulsification system"
RSC Advances 2020, 10(39):23058-23065
14. Ott Scheler, Karol Makuch, Pawel R Debski, Michal Horka, Artur Ruszczak, Natalia Pacocha, Krzystof Sozanski, Olli-Pekka Smolander, Witold Postek, Piotr Garstecki
"Droplet-based digital antibiotic susceptibility screen reveals single-cell clonal heteroresistance in an isogenic bacterial population"
Scientific Reports (2020) 10:3282
15. Karol Makuch, Robert Holyst, Tomasz Kalwarczyk, Piotr Garstecki, John F. Brady

"Diffusion and flow in complex liquids"
Soft Matter, 2020, 16, 114

16. Yu-Ting Kao, Tomasz S. Kaminski, Witold Postek, Jan Guzowski, Karol Makuch, Felix von Stetten, Roland Zengerle, and Piotr Garstecki
"Gravity-driven microfluidic assay for digital enumeration of bacteria and for antibiotic susceptibility testing"
Lab Chip, 2020, 20, 54
17. B. Chatterjee, J. Skolimowski, K. Makuch, and K. Byczuk
"Real-space dynamical mean-field theory of Friedel oscillations in strongly correlated electron systems"
Phys. Rev. B 100, 115118 (2019)
18. Karol Makuch, Jean Baptiste-Gorce, Piotr Garstecki
"Non-wetting droplets in capillaries of circular cross-section: scaling function"
Physics of Fluids 31, 043102 (2019)
19. Adam S. Opalski, Karol Makuch, Yu-Kai Lai, Ladislav Derzsi and Piotr Garstecki
"Grooved step emulsification systems optimize throughput of passive generation of monodisperse emulsions"
Lab Chip, 2019,19, 1183-1192
20. Magdalena A. Czekalska, Tomasz S. Kaminski, Karol Makuch, and Piotr Garstecki
"Passive and parallel microfluidic formation of droplet interface bilayers (DIBs) for measurement of leakage of small molecules through artificial phospholipid membranes"
Sensors and Actuators B: Chemical Volume 286, 1 May 2019, Pages 258-265
21. K. Makuch
"Generalization of Clausius-Mossotti approximation in application to short-time transport properties of suspensions"
Phys. Rev. E **92**, 042317 (2015)
22. K. Makuch, Przemysław Górka
Multipole matrix elements of Green function of Laplace equation
Acta Physica Polonica, B 46, 1487 (2015)
23. K. Makuch, Marco Heinen, Gustavo C. Abade, Gerhard Nägele
Rotational self-diffusion in suspensions of charged particles: Revised Beenakker-Mazur and Pairwise Additivity methods versus numerical simulations
Soft Matter, 2015, **11**, 5313 - 5326
24. K. Makuch, J. Skolimowski, P.B. Chakraborty, K. Byczuk, D. Vollhardt,
Thermodynamic properties of correlated fermions in lattices with spin-dependent disorder
New J. Phys. 15, 045031 (2013)
25. K. Makuch, B. Cichocki,
Transport properties of suspensions - critical assessment of Beenakker-Mazur method,
J. Chem. Phys. 137 184902 (2012)
26. K. Makuch,
Scattering series in mobility problem for suspensions,
J. Stat. Mech.: Theory Exp. 2012, P11016

PATENTS (GRANTED AND PENDING)

1. A. Opalski, K. Makuch., Yu-Kai Lai, P. Garstecki
"Microfluidic chip for production of monodisperse emulsions"
Pat. 238579 (Polish Patent Office)
2. (pending) M. Pilz, F. Nalin, K. Kwapiszewska, K. Makuch, L. Derzsi, R. Hołyst, P. Adamczuk “The method of measuring the penetration of particles into cells, the microfluidic system, the use of the microfluidic system.” Application number P.439015 (Polish Patent Office)

GRANTS AND FELLOWSHIPS

2022-2026	Grant holder and principal researcher in „Diffusion of rods and flexible polymers in complex fluids" grant „SONATA BIS 11" founded by National Science Center, Poland, funds: 1 465 952 PLN (c. 345 000 USD)
2018	Fellowship of the Polish National Agency For Academic Exchange for one year research at the California Institute of Technology, "Active matter inside droplet", 185 000 PLN
2017-2022	Grant holder and principal researcher in „Properties of complex liquids and their microscopic structure" grant „SONATA 11" founded by National Science Center, Poland, funds: 492 600 PLN
2016	Fellowship of the Kosciuszko Foundation for 4 month research at the California Institute of Technology, 12000 USD
2015-2016	Researcher in ""Microfluidic Combinatorial On Demand Systems: a Platform for High-Throughput Screening in Chemistry and Biotechnology" ERC Starting grant, five-year project, funds :1,75 mln EUR
2013-2015	Grant holder and principal researcher in „Macroscopic properties of dispersive media", grant founded by Polish Ministry of Science and Higher Education in frame of program „Iuventus Plus", two-year project, funds: 154 100 PLN
2011-2015	Researcher in "Predictive multi-scale simulations for correlated particles inside complex environments" led by dr hab. Krzysztof Byczuk, prof UW, funded by Foundation for Polish Science, four-year project, funds: 2 175 000 PLN

INVOLVMENT IN OTHER GRANTS

2021-2022	Work for TEAM-NET (Foundation for Polish Science) project "Platform for rapid label-free imaging, identification and sorting of leukemia cells" coordinated by prof. Czesław Radzewicz
2020-2022	Work for MAESTRO (National Science Centre, Poland) project "Microfluidic methods for quantitative antibiotic susceptibility assays with single cell resolution" led by prof. Piotr Garstecki
2021-present	Work for SONATA 14 (National Science Centre, Poland) project "Identification of the key genetic determinants of Staphylococcus aureus assosiated with bacteraemia infections" led by dr Marta Zapotoczna

AWARDS

- 2022: Best Paper Award published in 2021 by the Institute of Physical Chemistry of the Polish Academy of Sciences: Natalia Pacocha, Jakub Bogusławski, Michał Horka, Karol Makuch, Kamil Liżewski, Maciej Wojtkowski, and Piotr Garstecki, Anal. Chem. 2021, 93, 2, 843–850
- 2011: Ph.D degree cum laude
- 2009: Scholarship "Mazovian Ph.D. Scholarship"
- 2005: M.Sc. degree cum laude
- 2001-2005: Scholarship in Faculty of Physics, University of Warsaw (since the second year of studies)

CONFERENCE TALKS

1. 2024: "Diffusion and Flow in Complex Liquids"

2024 AIChE Annual Meeting, October 27, 2024 to October 31, 2024, San Diego, USA

2. 2024: “Thermodynamics of out of equilibrium steady states”
   2024 AIChE Annual Meeting, October 27, 2024 to October 31, 2024, San Diego, USA
3. 2024: “A dream about steady-state thermodynamics and how it is becoming a reality”
   John Brady Symposium, October 26, 2024, California Institute of Technology, Pasadena, USA (invited)
4. 2024: “Diffusion and Flow in Complex Liquids”
   27.09.2024, The Second Soft Matter Day, Warsaw, Poland
5. 2019: "Stokes’ law in complex liquids and inside cell cytoplasm"
   72nd Annual Meeting of the American Physical Society’s Division of Fluid Dynamics, November 23-26, 2019, Seattle, USA
6. 2019: "Stokes’ law in complex liquids and inside cell cytoplasm"
   Cell Physics 2019, 9-11.10.2019, Saarbrucken, Germany
7. 2018: “Stokes’ law in complex liquids and inside cell cytoplasm”
   7th European Conference on Computational Fluid Dynamics, Glasgow, Scotland, 11-15.06.2018
8. 2017: “Do bubbles screen?”
   So Cal Fluids XI, San Diego, USA, 22.04.2017
9. 2015: "Metal - Mott insulator heterostructures: real space dynamical mean-field study"
   Deutsche Physikalische Gesellschaft Spring Meeting, Berlin 16-20.03.2015
10. 2014: "Thermodynamics of simple cubic Hubbard model – dynamical mean-field study"
    From Spins to Cooper Pairs, 650th Jubilee of the Jagiellonian University, 22-26.09.2014, Zakopane, Poland
11. 2013: „Correlated lattice fermions in a spin-dependent random potential”
    Deutsche Physikalische Gesellschaft Spring Meeting, Regensburg 10.03.2013-15.03.2013

POSTER PRESENTATIONS

1. "Diffusion and flow in complex liquids"
   Colloidal, Macromolecular & Polyelectrolyte Solutions, GRC, Ventura, USA, 6-11.11.2022
2. "Stokes’ law in complex liquids"
   Colloidal, Macromolecular & Polyelectrolyte Solutions, GRC, Ventura, USA, 4-9.02.2018
3. “Stokes’ law in complex liquids”
   Frontiers in Physical Chemistry Symposium” Caltech, Pasadena, USA, 16-17.02.2017
4. “Stokes law in complex liquids”
   „6th Warsaw School of Statistical Physics”, Sandomierz, Poland, 25.06-02.07.2016
5. "Transport coefficients of suspensions of spherical particles"
   Nonequilibrium collective dynamics, Potsdam, Germany, 5-8.10.2015
6. "Metal - Mott insulator heterostructures: A dynamical mean field study"
   Correlated Electron Systems, GRC, South Hadley, USA, 22-27.06.2014,
7. "Transport coefficients for suspensions of spherical particles"
   Colloidal, Macromolecular & Polyelectrolyte Solutions, GRC, Ventura, USA, 16-21.02.2014
8. "Transport coefficients for suspensions of spherical particles"
   „*5th Warsaw School of Statistical Physics*”, Kazimierz Dolny, Poland,
9. "Transport coefficients for suspensions of spherical particles"
   STATPHYS25, 22-26.07.2013, Seoul, Republic of Korea
10. "Correlated lattice fermions in a spin-dependent random potential"
    „*The New Generation in Strongly Correlated Electron Systems*” 2013, Sestri Levante, Italy, 1–5.07.2013
11. „Approximate method of calculation of transport coefficients for suspensions”
    „2nd Warsaw School of Statistical Physics”, Kazimierz Dolny, Poland, 15.06.2007-22.06.2007

SELECTED SEMINAR TALKS (OVERALL MORE THAN 30)

1. “Unleashing the power of science in creating and shaping industries”
   Scope Fluidics, Warsaw, Poland, 24.08.2023
2. “A dream about new thermodynamics and how it is becoming a reality”
   Institute of Physical Chemistry, Warsaw, Poland, 19.05.2023, 31.05.2023
3. "Steady state thermodynamics"
   University of Warsaw, Faculty of Physics, Poland, 31.03.2023
4. “Global stationary thermodynamics”
   Pennsylvania State University, Department of Chemistry, S. Mallory group, USA, 18.11.2022
5. “Global stationary thermodynamics”
   California Institute of Technology, Department of Chemical Engineering, USA, 02.11.2022
6. “Speed of flow of non-wetting droplets in capillaries of circular cross-section – theory”
   Institute of Physical Chemistry, Polish Academy of Sciences, 15.03.2018
7. “Stokes’ law in complex liquids”
   California Institute of Technology, Department of Chemical Engineering, USA, 13.02.2018
8. “Homogenization theory in complex liquids”
   Simons Foundation, Flatiron Institute, New York, USA, 05.07.2017
9. “Short-time transport properties of suspensions of spherical particles”, University of Konstanz, Physics Department, Germany, 22.10.2015
10. “Transport properties of colloidal suspensions”, Princeton University, Department of Chemistry, USA, 26.03.2015
11. “Beenakker-Mazur expansion for suspensions of repulsive particles”, California Institute of Technology, Department of Chemical Engineering, USA, 25.02.2015
12. "Rotational self-diffusion in suspensions of repulsive particles"
    University of Warsaw, Faculty of Physics, Poland, 05.12.2014
13. "Transport coefficients for suspension of spherical particles"
    Warsaw University of Technology, Department of Mathematics and Information Sciences, Poland, 15.05.2014
14. "Thermodynamic properties of correlated fermions in lattices with spin-dependent disorder"
    Maria Curie-Skłodowska University, Institute of Physics, Lublin, Poland, 01.04.2014
15. "Structure and transport coefficients of charged and neutral colloidal particles"
    California Institute of Technology, Department of Chemical Engineering, USA, 13.02.2014
16. "Macroscopic properties of suspensions of spherical particles"
    Forschungszentrum Julich, Germany, 13.11.2013
17. "Tunnelling current through insulating barrier"
    University of Warsaw, Faculty of Physics, Poland, 18.06.2013
18. „Thermodynamic properties of correlated fermion in lattices with spin-dependent disorder”
    University of Warsaw, Faculty of Physics, Poland, 21.03.2013
19. „Hydrodynamic function and effective transport coefficients for suspension of spherical particles”
    Polish Academy of Sciences, Institute of Fundamental Technological Research, Poland, 21.12.2011
20. „Dynamical mean field theory"
    University of Warsaw, Faculty of Physics, Poland, 15.12.2011

RESEARCH VISITS

18-20.11.2024	Work with John Brady on soft and active matter, California Institute of Technology, USA
24.10.2024	Work with Zheng-Gang Wang on soft matter, California Institute of Technology, USA
16-18.11.2022	Work with Stewart A. Mallory on diffusion in complex liquids and active matter, Pennsylvania State University, USA
2-4.11.2022	Work with John Brady on diffusion in complex liquids and active matter, California Institute of Technology, USA
18.02-02.03.2018	Work with Dr. Marco Heinen on scattering of light in suspensions, University of

	Guanajuato, Mexico
12-16.02.2018	Work with John Brady on diffusion in complex liquids, California Institute of Technology, USA
29.05-02.06.2017	Work with dr hab. Anna Maciołek on diffusion of dimers in complex liquids, Max Planc Institute for Intelligent Systems, Stuttgart, Germany
19-23.10.2015	Work with Dr. Gustavo Coelho Abade on transport properties of suspensions, University of Konstanz, Germany
23-27.03.2015	Work with Dr. Marco Heinen on transport properties of suspensions of charged particles, California Institute of Technology, USA
12-15.11.2013	Work with prof. Gerhard Naegele and Dr. Marco Heinen on transport properties of suspensions of charged particles, Forschungszentrum Julich, Germany

LECTURES AND TEACHING EXPERIENCE

22,27.03.2018 University of Guanajuato "Hydrodynamics in Soft Matter" (4h)

Tutorials at the Faculty of Physics, University of Warsaw:

2014/2015	Green function method in condensed matter physics (tutorial, 30h)
2012/2013	Green function method in condensed matter physics (tutorial, 30h)
2007/2008	Continuum Mechanics (tutorial, 30h)
2007/2008	Classical Mechanics (tutorial, 30h)
2006/2007	Electrodynamics of material media (tutorial, 45h)
2006/2007	Statistical Mechanics (tutorial, 30h)
2005/2006	Phenomenological Thermodynamics (tutorial, 30h)
2005/2006	Statistical Physics (tutorial, 45h)

Others:

- 2010: START courses for students of Faculty of Physics, University of Warsaw (physics, 30h)
- 2006/2007: Course preparing for school leaving exam, Collegium Novum, Warsaw (mathematics, 45h)

STUDENTS SUPERVISION

- Uladzislau Sakalouski (PhD, Institute of Physical Chemistry, Polish Academy of Sciences, supervisor)
- Huma Jamil (PhD, Institute of Physical Chemistry, Polish Academy of Sciences, supervisor)
- Paulina Grodowicz, (2022, Batchelor in chemistry, Cardinal Stefan Wyszynski University, Poland, supervisor)
- Sara Zyskowska, (2022, Batchelor in chemistry, Cardinal Stefan Wyszynski University, Poland, supervisor)
- Michał Horka (2022, PhD in chemistry, Institute of Physical Chemistry, Polish Academy of Sciences, as a co-supervisor)
- Banhi Chatterjee (2017, PhD in physics, University of Warsaw, as a co-supervisor)
- Jean-Baptiste Gorce (2016, master internship in IPC PAS from ESPCI Paris, as a co-supervisor)

CONFERENCES AND WORKSHOPS

- 2024: "2024 AIChE Annual Meeting", October 27-31, 2024, San Diego, USA
- 2024: John Brady Symposium, California Institute of Technology, Pasadena, USA, 26.10.2024
- 2022: "Colloidal, Macromolecular & Polyelectrolyte Solutions", GRC, Ventura, USA, 6-11.11.2022
- 2019: 72nd Annual Meeting of the American Physical Society's Division of Fluid Dynamics, Seattle, USA

- 2019: Cell Physics 2019, Saarbrucken, Germany
- 2018: “7th European Conference on Computational Fluid Dynamics”, Glasgow, Scotland
- 2018: “Colloidal, Macromolecular & Polyelectrolyte Solutions”, GRC, Ventura, USA
- 2017 “Frontiers in Physical Chemistry Symposium”, Caltech, Pasadena, USA
- 2016: „6th Warsaw School of Statistical Physics”, Sandomierz, Poland
- 2015: “Nonequilibrium Collective Dynamics: Bridging the Gap between Hard and Soft Materials” Potsdam, Germany
- 2015: „Deutsche Physikalische Gesellschaft Spring Meeting”, Berlin, Germany
- 2014: "From Spins to Cooper Pairs", 650th Jubilee of the Jagiellonian University, Zakopane, Poland
- 2014: „Correlated Electron Systems”, GRC, South Hadley, USA
- 2014: „Colloidal, Macromolecular & Polyelectrolyte Solutions”, GRC, Ventura, USA,
- 2013: „International Conference on Statistical Physics”, Seoul, Republic of Korea
- 2013: „The New Generation in Strongly Correlated Electron Systems”, Sestri Levante, Italy
- 2013: „5th Warsaw School of Statistical Physics”, Kazimierz Dolny, Poland,
- 2013: „Deutsche Physikalische Gesellschaft Spring Meeting”, Regensburg, Germany
- 2009: „3rd Warsaw School of Statistical Physics”, Kazimierz Dolny, Poland,
- 2008: „7th Liquid Matter Conference”, Lund, Sweden,
- 2007: „International Soft Matter Conference”, Aachen, Germany
- 2007: „2nd Warsaw School of Statistical Physics”, Kazimierz Dolny, Poland,
- 2005: „1st Warsaw School of Statistical Physics”, Kazimierz Dolny, Poland

POPULARIZATION OF SCIENCE

- "Electricity from the Sun – photovoltaic cells (part I)" (in polish)
  Lecture, XVII Science Festival, Faculty of Physics, University of Warsaw, 28.09.2013
- „Magnetorheological liquid and fast off-road drive” (in polish)
  Lecture, XVI Science Festival, Faculty of Physics, University of Warsaw, 30.09.2012

OTHER ACTIVITY

- 2009: member of local organizing committee of „3rd Warsaw School of Statistical Physics”, Kazimierz Dolny, Poland,
- 2011: representative of Ph.D. students at Institute of Theoretical Physics Council at the Faculty of Physics University of Warsaw