

Helmut Ritsch

1.) Personal Data and short CV

Ritsch Helmut

[Researcher -ID: L-4704-2016,](#)

Theoretical Physics, University of Innsbruck

Date of birth: 12.03.1962

Nationality: Austria

URL for web site: <https://www.uibk.ac.at/th-physik/cqed/research.htm>

• EDUCATION

- 1993 Habilitation (venia docendi) in Theoretical Physics
- 1989 Ph.D. in Physics, Theoretical Physics Institute, University of Innsbruck, Austria
- 1986 Magister, University of Innsbruck, Austria

• CAREER POSITIONS

- 2011 – Professor, Theoretical Physics Institute,
University of Innsbruck & [Innsbruck Physics Research Center](#)
- 2009 – 2013 Head of Institute
- 1998 - 2011 Associate Professor
- 1993 – 1998 Universitätsdozent (Assistant Professor)
- 1989 – 1993 various Postdoc, research assistant positions and scholarships
in Innsbruck, Konstanz, Milano, Boulder, Munich

• FELLOWSHIPS AND AWARDS

- 2008 SUPA distinguished visitor award, Glasgow
- 2004 Dr. Otto Seibert Wissenschaftspreis
- 1993 Ludwig-Boltzmann-Award of the Austrian Physical Society
- 1992 Research Award of the City of Innsbruck

• SUPERVISION OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

- 22 Ph.-D.–students supervised in Innsbruck
- 15 Postdoctoral fellows from peer reviewed research grants
- 10 group members moved to faculty or tenure track positions:
Peter Horak (Southampton), *Peter Domokos* (Budapest), *Francesco Piazza*
(Dresden), *Claudiu Genes* (Erlangen), *Erez Boukobza* (Tel Aviv)
or senior scientist positions: *Hashem Zoubi* (Hannover), *Igor Mekhov* (Oxford),
Chiara Menotti (Trento), Janos Asboth & Andras Vukics (Wigner institute).

• TEACHING ACTIVITIES OVERVIEW

- 1993 – more than **35** main lecture courses for students in physics in Innsbruck
- 2003 & 2009 Guest professor for photonics + optoelectronics, TU Vienna
- 2004 Advanced school on field-atom surface interactions, Les Houches, France
- 2011 From C-QED with quantum gases to opto-mechanics,
TaCoNa-Photonics 2011, Bad Honnef

- **ORGANISATION OF SCIENTIFIC MEETINGS**

- 2002 - 2016 International Quantum Optics Conference in Obergurgl, 6x times chair / vice chair
 2013 Cavity Opto-mechanics: from micro- to macro scale, international workshop, Innsbruck
 2009 Cavity cooling of atoms, molecules and ions, CCQED-network conference, Obergurgl
 2006 ICAP – AMO Summer School, Innsbruck

- **INSTITUTIONAL RESPONSIBILITIES**

- 2009 – 2013 Head of Theoretical Physics Institute at University of Innsbruck
 2013 – Innsbruck Physics Doctoral School, [*Atom, Light and Molecules*](#), University of Innsbruck

- **COMMISSIONS OF TRUST**

- 2014 – Editorial Board, Journal of Physics B/ IOP/ GB
 2014- COST action Nanoscale Quantum Optics, Austrian representative in steering committee
 2010 COST Committee of Senior Officials
 2003 - Reviewing for national funding agencies: DFG Germany, ANR France, NSF USA, EPSRC GB, MIUR Italy, Marsden Fund, Fondecyt, Rustaveli, Foundation for Polish Science, Hungary, ESF Estonia
 2002 – Review panel member of various EU research programs as TMR, ITN, FET Open, EURYI, QIPC, ERC,
 ----- Journal referee for IOP, EPS, APS (outstanding referee), OSA, NPG, Science (AAAS), EPJD

- **MEMBERSHIPS OF SCIENTIFIC SOCIETIES**

- 1988 – Member of the Austrian Physical Society

- **COLLABORATIONS**

- FOQUS Research Centre (SFB) of Austrian Science Fund
- IQOQI Innsbruck university partner, Quantum Optics Group in Innsbruck & Vienna
- COLOPT:EU-ITN network collective scattering and selfordering
- Peter Domokos, Ultracold atom cavity QED, (EU_ITN), Wigner Institute, Budapest
- Tilmann Esslinger, Ultracold Gas Quantum Optics, (DACH & EU ITN) ETH, Zürich
- Giovanna Morigi & Jürgen Eschner, Selfordering in optical Resonators, (DACH Collaboration) Uni Saarbrücken
- Jun Ye & Murray Holland, DARPA-Quasar, atomic clocks, super-radiant lasers, JILA, Boulder
- Andreas Hemmerich, ultracold quantum gases in cavities, Universität Hamburg, Germany
- Sile Nic Chormaic, optical nanofibers, (EU STREP) , OIST, Okinawa, Japan
- Holger Müller group, Berkeley (recently started collaboration on Blackbody radiation forces in atomic meters)

2) Research summary:

2.1) Ongoing grants and recent funding summary:

<i>Project Title</i>	<i>Funding source</i>	<i>Amount (Euros)</i>	<i>Period</i>	<i>Role</i>	
FOQUS	FWF Austria	€ 1.073.903.-	2009 – 2018	PI	Ultracold quantum gas cavity QED
QSTRUCT	FWF DACH	€ 323.337.-	2015 – 2017	PI	Quantum crystals of light and matter
QUASAR	DARPA	\$ 385.000.-	2012 – 2017	PI	Quantum limits and corrections in an optical atomic lattice clock
NANO QO	EU-COST	open	2014 – 2018	MC-Member	nano-optics & near field forces with ultracold particles
ALM	FWF-Austria	€ 235.000.-	2016 – 2019	PI	<i>Atoms Light and Molecules</i> : doctoral training program including astrophysics lectures
COLOPT	EU	€ 273.278.-	2017 – 2020	PI	collective scattering and gas dynamics in optical resonators

2.2) Ph.D. projects finished and ongoing in last 5 years

- *Cavity QED with ensembles in superconducting cavities*, Kathrin Sandner
- *Self-consistent opto-mechanical Dynamics and Radiation Forces in Thermal Light Fields*, Matthias Sonnleitner ([Download PDF](#))
- *Collective Dynamics of Polarizable Particles and Electromagnetic Radiation*, Tobias Grießer ([Download PDF](#))
- *Hohlraum - QED mit ultrakalten Quantengasen*, Wolfgang Niedenzu
- *Cavity QED with few particles in multimode resonators* Raimar Sandner
- *Numerical simulation of multimode self-organization of cold atoms*, Sebastian Krämer
- *Atoms in magic wavelength lattices and superradiant lasing*, Laurin Osterman
- *Exploiting Collective Effects in a System of Interacting Quantum Emitters*, David Plankensteiner
- *Collective atomic dynamics in nanooptical devices* Daniela Holzmann
- *Quantum dynamics and simulation in multimode optical resonator systems*, Valentin Torggler
- *Nonlinear dynamics of ultracold quantum gases in laser fields* Stefan Ostermann

2.3 Selected publications (12):

chosen among >100 peer reviewed publications in 2006-2016 showing my current research interests

- *Spontaneous crystallization of light and ultracold atoms*, Ostermann, Stefan and Piazza, Francesco and Ritsch, Helmut, PRX, 6, 021026,(2016), [doi:10.1103/PhysRevX.6.021026](https://doi.org/10.1103/PhysRevX.6.021026)
- *Optimized geometries for future generation optical lattice clocks*, S. Krämer, L. Ostermann, H. Ritsch, ,EPL, 114, 14003, (2016), [doi:10.1209/0295-5075/114/14003](https://doi.org/10.1209/0295-5075/114/14003)
- *Nonequilibrium Phase Transition of Interacting Bosons in an Intra-Cavity Optical Lattice*, M. R. Bakhtiari, A. Hemmerich, H. Ritsch, M. Thorwart,, PRL 114, 123601, (2015) [doi:10.1103/PhysRevLett.114.123601](https://doi.org/10.1103/PhysRevLett.114.123601)
- *Self-ordering and collective dynamics of transversely illuminated point-scatterers in a 1D trap*, D. Holzmann, M. Sonnleitner, H. Ritsch, EPJD, 68, 352(2014), [doi:10.1140/epjd/e2014-50692-2](https://doi.org/10.1140/epjd/e2014-50692-2)
- *A superradiant clock laser on a magic wavelength optical lattice*, T. Maier, S. Krämer, L. Ostermann, H. Ritsch, Optics Express 22 11, 13269 (2014), [doi:10.1364/OE.22.013269](https://doi.org/10.1364/OE.22.013269)
- *Adaptive multifrequency light collection by self-ordered mobile scatterers in optical resonators*, V. Torggler, H. Ritsch, Optica 1, 5, 336(2014), [doi:10.1364/OPTICA.1.000336](https://doi.org/10.1364/OPTICA.1.000336)
- *Attractive optical forces from black-body radiation*, Sonnleitner, Matthias; Ritsch-Martel, Monika; Ritsch, Helmut; PRL,111,2,23601,2013, [doi:10.1103/PhysRevLett.111.023601](https://doi.org/10.1103/PhysRevLett.111.023601)
- *Cavity QED with Magnetically Coupled Collective Spin States*, R. Amsüss, et.al. , PRL, 107, 060502, (2011) [doi:10.1103/PhysRevLett.107.060502](https://doi.org/10.1103/PhysRevLett.107.060502)
- *Quantum gas of deeply bound ground state molecules*, Danzl, Johann G. et. al., Science,321,5892,1062-1066,2008, [doi:10.1126/science.1159909](https://doi.org/10.1126/science.1159909)
- *Probing quantum phases of ultracold atoms in optical lattices by transmission spectra in cavity quantum electrodynamics* Mekhov, Igor B; Maschler, Christoph; Ritsch, Helmut; Nature Physics 3,319,2007, [doi:10.1038/nphys571](https://doi.org/10.1038/nphys571)
- *Cold atom dynamics in a quantum optical lattice potential* Maschler, Christoph; Ritsch, Helmut; PRL ,95,26,260401,2005, [doi:10.1103/PhysRevLett.95.260401](https://doi.org/10.1103/PhysRevLett.95.260401)
- *Strong magnetic coupling of an ultracold gas to a superconducting waveguide cavity* Verdú, J; Zoubi, H; Koller, Ch; Majer, J; Ritsch, H; Schmiedmayer, J; PRL,103,4,043603,2009, [doi:10.1103/PhysRevLett.103.043603](https://doi.org/10.1103/PhysRevLett.103.043603)

Invited review papers:

- *Cold atoms in cavity-generated dynamical optical potentials*, Ritsch, Helmut; Domokos, Peter; Brennecke, Ferdinand; Esslinger, Tilman; Reviews of Modern Physics,85,2,553 (2013) [doi:10.1103/RevModPhys.85.553](https://doi.org/10.1103/RevModPhys.85.553)
- *Quantum optics with ultracold quantum gases: towards the full quantum regime of the light-matter interaction*, IB Mekhov, H Ritsch, Journal of Physics B: AMO, 45 (10), 102001 (2012), [doi:10.1088/0953-4075/45/10/102001](https://doi.org/10.1088/0953-4075/45/10/102001)
- *Excitons and cavity optical lattice ultracold atoms* H Zoubi, H Ritsch, Advances in Atomic, Molecular, and Optical Physics 62, 171 (2013) [doi:10.1016/B978-0-12-408090-4.00003-7](https://doi.org/10.1016/B978-0-12-408090-4.00003-7)

2.4) Conferences Talks:

Invited presentations to peer-reviewed, internationally established conferences:

selection from talks 2010-2016:

- *Spontaneous crystallisation of a BEC and light in 1D trap*, [Quantum Simulations and Many-Body Physics with Light](#) (Chania, Crete, Greece, June 4 - 11, 2016) (2016)
- *A self-ordered atom–photon crystal in 3D via collective coherent backscattering*, [Strongly disordered optical systems: from the white paint to cold atoms](#) (Cargese, France, September 26-30, 2016) (2016)
- *Cavity ground state cooling: from opto-mechanics to ultracold quantum gases*, [Advanced atomic sources and extreme cooling of atoms and molecules: techniques and applications](#) (Les Houches, France, January 24 - 29, 2016) (2016)
- *Spontaneous crystallization of light and ultracold atoms in free space*, [CoScaLi IV: Workshop on Collective Scattering of Light](#) (Ubatuba, Brazil, May 9 - 12, 2016) (2016)
- *Selfordering and Adaptive Light Collection by Mobile Scatterers in Resonators*, [Discussions on Nano & Mesoscopic Optics](#) (El Chaltén, Patagonia, Argentina, April 2015)
- *Subrecoil cooling and atomic selfordering in high Q cavities: a numerical study*, [Quantum dynamics in systems with many coupled degrees of freedom: challenges for theory](#) (Hamburg, Germany, March 24-26, 2014)
- *Selfordering and long range interactions in cavities*, [CCQED meeting](#) (Aarhus, Denmark, October 29-31, 2014)
- *From cavity QED with quantum gases to optomechanics*, [Optomechanics on the Hudson](#) (keynote tutorial, New York, USA, April, 2-4, 2012)
- *Ultracold Quantum Particles in Cavity Generated Optical Lattices*, [KITP Program: Beyond Standard Optical Lattices](#) (Santa Barbara, USA, September, 13 - December, 10, 2010)
- *Cavity QED with ultracold quantum gases*, [22nd International Conference on Atomic Physics](#) (plenary, Cairns, Australia)

Selected recent workshops and meetings:

- *Attractive optical forces from black-body radiation*, [Optics in Life Sciences Congress](#) (Waikoloa, Hawaii, USA, April, 14-18, 2013)
- *Optical-transition clocks with micro-fabricated frequency combs for performance beyond the standard quantum limit*, [Quantum Assisted Sensing And Readout \(QuASAR\)](#) (Long Beach, USA, January 2014)
- *Selfordering and long range interactions in cavities*, [Quantum Science: Implementations](#) (Benasque, Spain, July 2014 and July 2016)
- *Optical-transition clocks with micro-fabricated frequency combs for performance beyond the standard quantum limit*, Quantum Assisted Sensing And Readout (QuASAR) Program Review Meeting (Boulder, CO, USA, April 6 - 8, 2016) (2016)

2.5) Short summary of recent research activities

The general focus of my recent research at the Institute for Theoretical Physics in Innsbruck is concentrated on Atomic, Molecular and Optical physics (AMO) with emphasis on quantum optics, cavity QED, ultracold quantum gases and fundamental quantum physics.

In my research group in the past years we have developed foundational contributions on cavity cooling, ranging from applications for degenerate ultra-cold gases, mixed atomic gases, large molecules, nano-particles to quantum opto-mechanics. In this research area a great deal of the theoretical foundations was developed by us in Innsbruck including simplified models to combine the research areas of quantum optics, cavity QED and ultra-cold gas physics.

Ultracold gases confined in high Q resonators are an ideal test ground to study mesoscopic nonlinear quantum dynamics of open systems. Recently we could show that they but bear great potential as general purpose quantum simulators or to implement scalable systems for quantum annealing.

As prominent example for which we laid the foundations in Innsbruck, we studied atom-field self-ordering phenomena as an example of open system phase transitions. In the quantum regime this amounts to the quantum phase transitions from a superfluid towards new ordered or crystalline phases as for example a super solid phase. The underlying dynamical symmetry breaking can also create exotic states as measurement induced macroscopic super-positions. Several of these surprising phenomena are experimentally confirmed in the meantime in the thermal and zero temperature regime.

Besides such fundamental theoretical aspects of light-matter interaction, my research interests also strongly target experimental and practical applications of lasers and light in a wider optics area. Recent studies range from propositions of laser cooling of solids, heat gradient driven lasing to self-optimizing and learning light collection systems.

In conjunction with the world leading groups in Boulder and Harvard a major effort was devoted to study the ultimate limitations of optical atomic clocks based on ultracold magic wavelength lattices. Several of our recent proposals target at further improvements using collective states and super radiant lasing as future time and frequency standard.

Beyond the standard quantum optics we recently also studied a new class of light forces induced by broad band fields and black body radiation. These have surprising properties as attractive components towards hot objects with potential applications in astrophysics as well as nano-optics and nano-mechanics.

A complete detailed account of the corresponding published work can be found under my [Researcher -ID: L-4704-2016](#), or on google scholar.

3) Teaching summary

I taught more than **35** main lecture courses (>10 in the last 5 years) for students in physics in Innsbruck at all levels from introductory mechanics to PhD courses.

I personally and directly supervised 22 PhD students (7 in last 5 years) and 6 master theses as detailed above and in the attachment. For more details on my teaching in the last 5 years *see attached teaching account "Meine Lehre"*

4) Administration and management

From 2009 to 2013 I was Head of Institute of Theoretical Physics, a time during which two new full professors were hired and several young scientists became associate professors fulfilling their QV qualifications. Members of the institute attained several ERC and START prizes. Altogether it was a scientifically very successful period with significant growth of the institute.

The time also involved the ongoing preparations for moving the institute to the new "Haus der Physik", which after some delays happened soon after my duty period. During this time I was also strongly involved in the development of the current active "Entwicklungsplan" for the future development of the faculty and the university.

During the past five years I fully managed a group with several Postdocs and four to six PhD. students, all fully funded from external grants. Several external scientists joined the group using Lise Meitner fellowships or APART scholarships of the Austrian Academy of Sciences.

Naturally I was also a member of numerous committees on institute, faculty or university level as well as on the COST Committee of Senior Officials in Brussels.

5) Strongholds, challenges and future development

In my group throughout the years that greatest stronghold was that I was always able to attract outstanding students and Postdocs at all levels. The strong and internationally renowned Quantum Optics and ultra-cold atoms groups at Innsbruck University, the theory institute and IQOQI with their international visibility created an ideal basis here. All my PhDs finished their work with outstanding results and best grades. Thus many are now on faculty, tenure track or senior scientist positions. Also two local, very successful young high tech companies, Phion/Barracuda and Synedra, were largely cofounded by PhDs and Postdocs from my group.

While such successful offspring is certainly positive and desired in general, it is also always accompanied by a strong loss of know how. As there is and were no university funded or long term positions in my group, I was not even able to keep the best for some time longer and build a large group of even bigger international impact. Similarly the very limited access to secretarial and dedicated administrative support limited my available time for high level planning and research and thus hindered some extra promising developments.