Curriculum Vitæ *updated: April 28, 2023*

Philipp M. Schicho

1. Personal information

name	Dr. Philipp Maximilian Schicho born in Graz, Austria, 01 October 1991
nationality	Austrian
address	Max-von-Laue-Strasse 1 60438 Frankfurt am Main, Germany
email	schicho@itp.uni-frankfurt.de
website	pschicho.github.io
inspire HEP	inspirehep.net/authors/1639147
google scholar	scholar.google.com/citations?user=6BI62ioAAAAJ
ORCID iD	0000-0001-5869-7611
phone	+49 (69) 798 47891

2. Current position

09/2022 – today Postdoctoral researcher
Institute for Theoretical Physics, Goethe University Frankfurt
Advisors: L. Sagunski, J. Schaffner-Bielich

3. Employment history

05/2020 – 08/2022 Postdoctoral researcher
Helsinki Institute of Physics, University of Helsinki
Advisors: A. Vuorinen, K. Rummukainen

02/2017 – 04/2020 Doctor of Philosophy, PhD Physics (magna cum laude), 23/04/2020
AEC, Institute for Theoretical Physics, University of Bern
Advisor: M. Laine
Thesis: *Multi-loop investigations of strong interactions at high temperatures*, (cf. research output [4]).

10/2016 – 01/2017 Technical student
CERN, Accelerator and Beam Transfer, Beam Transfer Physics
Theoretical optimisation of slow extraction (cf. research output [6]).
Advisors: M.A. Fraser, M. Meddahi

06/2015 – 08/2015 Summer student
CERN, ABT, BTP
Thesis: *Optimising simulation times of SPS slow extraction using* `MAD-X`, (cf. research output [5]).

07/2014 – 08/2014 Summer student (GPA 1.0/1.0)
HEPHY, Institute of High Energy Physics, Vienna
Advisor: R. Schöfbeck
Thesis: *Increasing the sensitivity of a search for supersymmetry in the single lepton channel with the Stransverse Mass* M_{T2} (CMS), (cf. research output [1]).

4. Education

07/2017 École de physique des Houches
Effective Field Theory (EFT) in particle physics and cosmology

03/2017 Computer algebra and particle physics (CAPP) school, DESY, Hamburg

09/2014 – 11/2016 Master of Science, MSc Physics (GPA 5.5/6.0), 01/11/2016
ETH Zürich, Switzerland
Major: Theoretical high energy physics, lattice QCD, applied mathematics
Advisor: P. de Forcrand
Thesis: *Inhomogeneous condensation in quark-based QCD effective models via wavelet pseudoparticles*, (cf. research output [3]).

07/2014 LAPP Annecy-le-Vieux, France
Summer School in Particle and Astroparticle physics

08/2013 Theoretical Physics Summer school, University of Utrecht, Netherlands

09/2011 – 08/2014 Bachelor of Science, BSc Physics (with distinction, GPA 1.1/1.0), 12/08/2014
Graz University of Technology, Austria
Advisors: H. G. Evertz, C. B. Lang
Thesis: *π- and ρ-Meson mass spectroscopy from Lattice QCD*, (cf. research output [2]).

09/2002 – 05/2010 Österreichische Reifeprüfung, Matura (with distinction, GPA 1.0/1.0)
AHS BG/BRG Leibnitz, Austria
Major: Physics and geometry
Advisor: H. Scherz
Thesis: *Sonoluminescence – A bubble's enlightenment.* A theoretical and experimental approach to the effect of Sonoluminescence.

5. Teaching activities

03/2022 *Phase transitions in the early universe* (exercises)
Galileo Galilei Institute for Theoretical Physics
Theoretical Aspects of Astroparticle Physics, Cosmology and Gravitation

2021 – MSc thesis supervisor,
Helsinki Institute of Physics, University of Helsinki

Sami Vihko, 06/2021 – 03/2022, co-supervised with A. Vuorinen
Thesis: *EFT methods and calculational techniques in imaginary time formalism of thermal QCD.*

2022 – BSc thesis supervisor,
Institute for Theoretical Physics, Goethe University Frankfurt

Rebecca Baumann, 10/2022 – co-supervised with L. Sagunski, D. Schmitt

2013 – Teaching assistant

Institute for Theoretical Physics, Goethe University Frankfurt
Astrophysics II

AEC, Institute for Theoretical Physics, University of Bern
Quantum theory I/II, the Standard Model, statistical mechanics, introduction to BSM physics, theoretical exercises

ETH Zürich, D-MATH/D-PHYS
Numerical mathematics I, Numerical methods, Physics I

Graz University of Technology, ITP/IEP
Theoretical mechanics, physics laboratory I/II

6. Outreach

11/2022 Event organisation, Goethe University Frankfurt
WOW Physics! (Women Of the World in Physics!)

09/2017 Public research display, University of Bern
Nacht der Forschung (NdF)

7. Research visits

12/2022 Kavli IPMU, Tokyo; G. White

09/2022 Jožef Stefan Institute, Ljubljana; M. Nemevšek

06/2022 SUBATECH, Nantes; J. Ghiglieri

10/2021 University of Basel; S. Antusch

10/2021 University of Bern, AEC, Institute for Theoretical Physics; M. Laine

08/2019 University of Helsinki, Helsinki Institute of Physics; A. Vuorinen, K. Rummukainen

08/2018 Universidad del Bío-Bío, Grupo de Cosmología y Partículas Elementales; Y. Schröder

8. Professional services

03/2022– Referee
American Physical Society's journals: Phys. Rev. **D**, Phys. Rev. **L**
Springer's journals: Eur. Phys. J. **C**

9. Scientific research skills

Theoretical (Dimensionally reduced) effective field theories, thermal field theory, quantum field theory, Lattice QCD, simulations in physics, computer algebra techniques, general relativity, cosmology, string theory, conformal field theory, group theory

Computational `C/C++`, `Python`, `Matlab`, `FORM`, `ROOT`, `FORTRAN 77`, Unix, Linux, Mathematica, LaTeX, computer hardware, `HTML`, Office, CAD-Software

10. Prizes, awards, fellowships

2011 – 2014 Scholarship of excellence Graz University of Technology
(EUR 800 scholarship p.a.)

11. Languages

German Mother-tongue

English Proficient C2, TOEFL 106/120 (2014), Cambridge ESOL B2 First FCE (2010)

Spanish Intermediate B1

Danish Elementary A2

French Beginner A1

Latin Very good (literal translation)

12. Major scientific achievements

Precision thermodynamics for cosmological phase transitions.

Invigorated by the first gravitational wave (GW) detections from binary mergers, I dedicated a large part of my first postdoc pushing the accuracy of the thermodynamics of cosmological phase transitions. In my first post-doctoral project, I assessed the theoretical uncertainties for cosmological phase transitions in [11]. The motivation for such a theoretical leap in precision was that leading-order (LO) calculations of thermodynamics are insufficient and render the GW spectrum ambiguous. An innocuous uncertainty at early stages has far-reaching effects in the beyond the Standard Model (BSM) – GW pipeline and put successful stochastic gravitational wave background (SGWB) observations at LISA at risk before they even begin.

The work in [11] established the current state-of-the-art precision for GW predictions. This level of precision was achieved by using methods of dimensionally reduced EFT to derive the Standard Model EFT (SMEFT) three-dimensional effective potential and its minimisation.

Development of automated 3d EFT framework for thermal field theories.

To improve the overall understanding of such EFT computations, we put forward a didactic review on the robust approach to thermal resummation as a combination between perturbative and non-perturbative techniques [10]. By inspecting the (dynamical) real singlet extension to the Standard Model, I computed novel contributions to the parameters of the dimensionally reduced EFT at next-to-leading order (NLO) which will be applicable for future non-perturbative lattice studies of the model. While, we demonstrated that two-loop contributions in the matching and effective potential are substantial [12] for robust predictions of the thermodynamic phase transition parameters, we also devised a minimal setup [17] that combines gauge invariance and resummation and supersedes a previous scheme.

In this context, I automated the evaluation and reduction of analytically challenging sum-integrals at non-zero temperature. The automation via the corresponding `Mathematica` package `DRalgo` [20], is now successfully applied not only in QCD but also in the **most accurate predictions of gravitational waves** from cosmological first-order phase transitions in generic BSM theories.

Gauge-invariant framework for nucleation at finite temperature.

Theoretical uncertainties when determining the finite-temperature nucleation rate of bubbles of the new stable vacuum are still substantial. Especially in the context of radiatively induced transitions, I resolved a long-standing problem related to the unphysical gauge-dependence of the bubble nucleation rate. By employing effective theories at the nucleation scale for the Abelian Higgs model, I demonstrated for the first time [15, 13] gauge invariance of the leading order (LO) perturbative contributions in radiatively induced transitions.

Research output list

If not specifically indicated otherwise, the following research list is in alphabetical order. In all subsequent research output, I contributed at the level of first or second author, conducted the computations, (co-)led the writing, and developed the main ideas of the project.

Journal articles

[22] J. Österman, **P. Schicho**, and A. Vuorinen, *Integrating by parts at finite density*, (2023), [2304.05427].

[21] L. Sagunski, **P. Schicho**, and D. Schmitt, *Supercool exit: Gravitational waves from QCD-triggered conformal symmetry breaking*, (2023), [2303.02450].

[20] A. Ekstedt, **P. Schicho**, and T. V. I. Tenkanen, `DRalgo`*: A package for effective field theory approach for thermal phase transitions*, Comput. Phys. Commun. **288**, 108725 (2023), [2205.08815].

[19] T. Gorda, A. Kurkela, J. Österman, R. Paatelainen, S. Säppi, **P. Schicho**, K. Seppänen, and A. Vuorinen, *Degenerate fermionic matter at N3LO: Quantum electrodynamics*, Phys. Rev. D **107**, L031501 (2023), [2204.11893].

[18] T. Gorda, A. Kurkela, J. Österman, R. Paatelainen, S. Säppi, **P. Schicho**, K. Seppänen, and A. Vuorinen, *Soft photon propagation in a hot and dense medium to next-to-leading order*, Phys. Rev. D **107**, 036012 (2023), [2204.11279].

[17] **P. Schicho**, T. V. I. Tenkanen, and G. White, *Combining thermal resummation and gauge invariance for electroweak phase transition*, JHEP **11**, 047 (2022), [2203.04284].

[16] S. Biondini, **P. Schicho**, and T. V. I. Tenkanen, *Strong electroweak phase transition in t-channel simplified dark matter models*, JCAP **10**, 044 (2022), [2207.12207].

[15] J. Hirvonen, J. Löfgren, M. J. Ramsey-Musolf, **P. Schicho**, and T. V. I. Tenkanen, *Computing the gauge-invariant bubble nucleation rate in finite temperature effective field theory*, JHEP **07**, 135 (2022), [2112.08912].

[14] J. Ghiglieri, G. D. Moore, **P. Schicho**, and N. Schlusser, *The force-force-correlator in hot QCD perturbatively and from the lattice*, JHEP **02**, 58 (2022), [2112.01407].

[13] J. Löfgren, M. J. Ramsey-Musolf, **P. Schicho**, and T. V. I. Tenkanen, *Nucleation at finite temperature: a gauge-invariant, perturbative framework*, (2021), [2112.05472].

[12] L. Niemi, **P. Schicho**, and T. V. I. Tenkanen, *Singlet-assisted electroweak phase transition at two loops*, Phys. Rev. D **103**, 115035 (2021), [2103.07467].

[11] D. Croon, O. Gould, **P. Schicho**, T. V. I. Tenkanen, and G. White, *Theoretical uncertainties for cosmological first-order phase transitions*, JHEP **04**, 055 (2021), [2009.10080].

[10] **P. M. Schicho**, T. V. I. Tenkanen, and J. Österman, *Robust approach to thermal resummation: Standard Model meets a singlet*, JHEP **06**, 130 (2021), [2102.11145].

[9] M. Laine, **P. Schicho**, and Y. Schröder, *A QCD Debye mass in a broad temperature range*, Phys. Rev. D **101**, 023532 (2020), [1911.09123].

[8] M. Laine, **P. Schicho**, and Y. Schröder, *Soft thermal contributions to 3-loop gauge coupling*, JHEP **2018**, 37 (2018), [1803.08689].

Conference proceedings

[7] G. Aarts, J. Aichelin, C. Allton, A. Athenodorou, D. Bachtis, C. Bonanno, N. Brambilla, E. Bratkovskaya, M. Bruno, M. Caselle, C. Conti, R. Contino, L. Cosmai, F. Cuteri, L. Del Debbio, M. D'Elia, P. Dimopoulos, F. Di Renzo, T. Galatyuk, J. N. Guenther, R. Houtz, F. Karsch, A. Y. Kotov, M. P. Lombardo, B. Lucini, L. Maio, M. Panero, J. M. Pawlowski, A. Pelissetto, O. Philipsen, A. Rago, C. Ratti, S. M. Ryan, F. Sannino, C. Sasaki, **P. Schicho**, C. Schmidt, S. Sharma, O. Soloveva, M. Sorba, and U.-J. Wiese. *Phase Transitions in Particle Physics – Results and Perspectives from Lattice Quantum Chromo-Dynamics*. In (Jan. 2023). [2301.04382].

[6] M. Fraser, D. Björkman, K. Cornelis, B. Goddard, V. Kain, **P. Schicho**, C. Theis, and H. Vincke. *Modelling the Radioactivity Induced by Slow-Extraction Losses in the CERN SPS*. In *Proc. of International Particle Accelerator Conference (IPAC'17)* (May 2017), 1897–1900.

[5] M. A. Fraser, R. G. Alia, B. Balhan, H. Bartosik, C. Bertone, D. Björkman, J. Borburgh, N. Conan, K. Cornelis, L. Gatignon, B. Goddard, Y. Kadi, V. Kain, A. Mereghetti, F. Roncarolo, **P. M. Schicho**, J. Spanggaard, O. Stein, L. Stoel, F. M. Velotti, and H. Vincke. *SPS Slow Extraction Losses and Activation: Challenges and Possibilities for Improvement*. In *Proc. of International Particle Accelerator Conference (IPAC'17)* (Copenhagen. 2017), 611–614.

Theses

[4] **P. M. Schicho**, *Multi-loop investigations of strong interactions at high temperatures*, PhD thesis (U. Bern, 2020).

[3] **P. M. Schicho**, *Inhomogeneous condensation in quark-based QCD effective models via wavelet pseudoparticles*, MA thesis (ETH Zürich, 2016).

[2] **P. Schicho**, *π- and ρ-Meson mass spectroscopy from Lattice QCD*, BA thesis (TU Graz, 2014).

[1] **P. Schicho**, *Increasing the sensitivity of a search for supersymmetry in the single lepton channel with the Stransverse Mass*, Project thesis (HEPHY Vienna, 2014).

Invited talks at workshops

05/12/2022 *EFT framework for (precision) cosmological phase transition thermodynamics*, invited **planary** talk at *What the heck happens when the Universe boils?* at Kavli

IPMU, Tokyo, Japan

Seminar and contributed talks

05/05/2023 *Strong electroweak phase transition and simplified dark matter models*, contributed talk at Progress on Old and New Themes in cosmology (PONT) 2023, Avignon, France

25/01/2023 *Degenerate fermionic matter at N^3LO*, invited seminar talk at Gravitation and Cosmology seminar, Utrecht University, Netherlands

24/01/2023 *What can EFT tell us about the electroweak phase transition?*, seminar talk at CRC-TR211 meeting and Colloquium, Bielefeld University, Germany

08/11/2022 *EFT framework for cosmological phase transition thermodynamics*, seminar talk at the AstroCoffee, Goethe University, Frankfurt, Germany

13/10/2022 *Degenerate fermionic matter at N^3LO*, invited seminar talk (online) at S@INT seminar, INT, Seattle, USA

15/09/2022 *(Gauge independent) Bubble nucleation rate at finite temperature*, invited seminar talk at Jožef Stefan Institute, Ljubljana, Slovenia

24/08/2022 *Can EFT tell us if there was an electroweak phase transition?*, invited seminar talk at University of Graz, Graz, Austria

11/07/2022 *Soft light-cone observables from electrostatic QCD*, invited seminar talk (online) at the QCD theory seminar

07/07/2022 *Degenerate fermionic matter at N^3LO*, invited seminar talk at the Nuclear Physics Colloquium, Goethe University, Frankfurt, Germany

20/06/2022 *Jet dispersion in hot QCD from the lattice*, contributed talk at SEWM 2022, Paris, France

16/06/2022 *Can EFT tell us if there was an electroweak phase transition?*, invited seminar talk at SUBATECH, Nantes, France

31/05/2022 *Electroweak phase transition: Combining thermal resummation and gauge invariance*, invited seminar talk at NICPB, Tallinn University, Estonia

24/05/2022 *Combining thermal resummation and gauge invariance for electroweak phase transition*, invited seminar talk (online) at School of Physics and Astronomy, Monash University, Australia

06/04/2022 *(Non-)perturbative jet dispersion hot QCD*, contributed talk at Quark Matter 2022, Kraków, Poland

30/03/2022 *(Non-)perturbative jet dispersion hot QCD*, contributed talk at Mini workshop: Phase transitions in particle physics, Galileo Galilei Institute, Firenze, Italy

03/03/2022 *Effective theory approach to cosmological phase transitions*, invited seminar talk at Instituto de Astrofísica de Canarias, La Laguna, Spain

28/10/2021 *Gauge independent bubble nucleation rate at finite temperature*, invited seminar talk at University of Basel, Basel, Switzerland

19/10/2021 *Cosmological phase transition: Robust thermal resummation*, invited seminar talk at University of Bern, Bern, Switzerland

13/05/2021 *Cosmological phase transition: Robust thermal resummation*, invited seminar talk (online) at KIAS, Seoul, South Korea

29/03/2021 *Soft thermal contributions to 3-loop gauge coupling*, contributed parallel talk at FunQCD (online), Barcelona, Spain

25/11/2020 *How to be precise at the electroweak scale at finite-temperature*, invited seminar talk (online) at Kavli IPMU, Tokyo, Japan

13/08/2019 *3-Loop Gauge Coupling in Hot Yang-Mills*, invited seminar talk at Helsinki Institute of Physics, Helsinki, Finland

28/08/2018 *Fun with thermal dimension-six operators*, invited seminar talk at Universidad del Bío-Bío, Chillán, Chile

28/06/2018 *Fun with thermal dimension-six operators*, contributed parallel talk at SEWM 2018, Barcelona, Spain