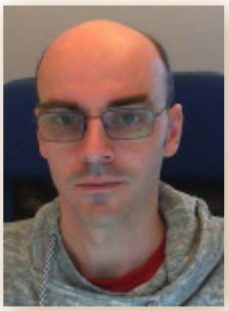
# Matthias Hoelzl



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## Research Interests

With the group in Garching and in various international collaborations, we study **large-scale instabilities in tokamak plasmas aiming to develop predictive capabilities for ITER and DEMO**. Simulations in particular with the **non-linear extended MHD code JOREK** (see here) allow to interpret and predict the non-linear dynamics of such instabilities in magnetically confined fusion plasmas. The focus is on studies of **edge localized modes** (ELMs), **disruptions**, vertical displacement events (VDEs), tearing modes, **runaway electrons**, and techniques for the control, suppression, or mitigation of these phenomena. The physics models and numerical methods used in the code are continuously developed further. The research is carried out in a strong international team with collaborations worldwide. **A comprehensive overview of the JOREK code and its applications** has been submitted to Nuclear Fusion, a pre-print is available here.

## Curriculum Vitae

- Since 2020: Principle Investigator of the (proposed) EUROfusion Theory and Simulation Verification and Validation (TSVV) Project on MHD Transients running over five years and including 25 contributors from nine European countries (plus future contributors from advanced computing hubs).
- Since 2019: Deputy group leader MHD and fast particles at Max Planck Institute for Plasma Physics.
- Since 2015: Principal Investigator of two EUROfusion Enabling Research Projects with more than 30 contributors.
- Since 2013: Staff scientist at Max Planck Institute for Plasma Physics.
- 2010 to 2013: Postdoctoral Researcher at Max Planck Institute for Plasma Physics including research stays at CEA/IRFM Cadarache and ITER Organization.
- 2010: PhD in physics from Technical University Munich: *Diffusive Heat Transport across Magnetic Islands and Stochastic Layers in Tokamaks*

## Project Grants

Full list at matthias-hoelzl.org/projects.html

- Hoelzl M. (Task Leader), Huijsmans G.T.A., Artola F.J., Atanasiu C., Becoulet M., Bonfiglio D., Bardsley O., Cathey A., Fil A., Futatani S., Gruca M., Guillard H., Korving S., Kos L., Krebs I., Lu Z., Nardon E., Nkonga B., Pamela S., Penko D., Rubinacci G., Sadouni S., Schwarz N., Villone F., Wieschollek F., and several contributors from advanced computing hubs. – *Integrated Modelling of Transient MHD Events.* – **EUROfusion Theory, Simulation, Verification and Validation (TSVV) Task** (1/2021–12/2025; proposed).
- Hoelzl M. (PI), Bandaru V., Artola F.J. – *Self-consistent fluid simulations of runaway electrons and non-linear MHD during disruptions for ITER.* – **ITER project** (9/2020–8/2022).
- Hoelzl M. (PI), Lu Z., Bandaru V., Holod I., Singh Verma P., Hindenlang F., Cathey A., Nikulsin N., Ramasamy R., Wieschollek F., Schwarz N., Huijsmans G.T.A., Nardon E., Gruca M., Artola-Such J. – *Computing time for non-linear MHD simulations of disruptions and ELMs and developments for code efficiency and stellarator geometry.* – Marconi-Fusion Supercomputer (03/2020–02/2021).
- Singh Verma P., Hoelzl M., Huijsmans G.T.A. – *Optimization of the efficiency and scalability of the solver in the non-linear MHD code JOREK.* – EUROfusion High Level Support Team Project (7/2019–12/2020).
- Hoelzl M. (PI), Huijsmans G.T.A., Atanasiu C.V., Bandaru V.K., Becoulet M., Bhole A., Cathey A., Dvornova A., Franck E., Futatani S., Guillard H., Latu G., Liu F., Nardon E., Nkonga B., Pamela S., Passeron C., Smith S., Strumberger E., van Vugt D. – *Strengthening the non-linear MHD code JOREK for application to key questions of the fusion roadmap.* – **EUROfusion Enabling Research Project** (1/2019–12/2020).

# Publications

Full list at matthias-hoelzl.org/publications.html

- Hoelzl M., Huijsmans G.T.A., Pamela S.J.P., Becoulet M., Nardon E., Artola F.J., Nkonga B., Atanasiu C.V., Bandaru V., Bhole A., Bonfiglio D., Cathey A., Czarny O., Dvornova A., Feher T., Fil A., Franck E., Futatani S., Gruca M., Guillard H., Haverkort J.W., Holod I., Hu D., Kim S.K., Korving S., Krebs I., Kripner L., Latu G., Merkel P., Meshcheriakov D., Mitterauer V., Mochalskyy S., Morales J.A., Nies R., Nikulsin N., Orain F., Pratt J., Ramasamy R., Ramet P., Reux C., Schwarz N., Sing Verma P., Smith F., Sommariva C., Strumberger E., van Vugt D., Verbeek M., Westerhof E., Wieschollek F., Zielinski J. – *The JOREK non-linear extended MHD code and applications to large-scale instabilities and their control in magnetically confined fusion plasmas.* – Nuclear Fusion (submitted) arXiv:2011.09120
- Cathey A., Hoelzl M., Futatani S., Lang P.T., Lackner K., Huijsmans G.T.A., Pamela S.J.P., Günter S., JOREK Team, ASDEX Upgrade Team, EUROfusion MST1 Team. – *Comparing natural and pellet triggered ELMs via non-linear extended MHD simulations.* – Plasma Physics and Controlled Fusion (submitted)
- Artola F.J., Sovinic C.R., Jardin S.C., Hoelzl M., Krebs I., Clauser C. – *3D simulations of vertical displacement events in tokamaks: A benchmark of M3D-C1, NIMROD and JOREK.* – Physics of Plasmas (submitted) arXiv:2011.04523
- Bandaru V., Hoelzl M., Reux C., Ficker O., Scott S., Lehnen M., Eidietis N., JOREK Team, JET Contributors. – *Magnetohydrodynamic simulations of runaway electron beam termination in JET.* – Plasma Physics and Controlled Fusion 63, 035024 (2021)
- Hu D., Nardon E., Hoelzl M., Wieschollek F., Lehnen M., Huijsmans G.T.A., van Vugt D.C., Kim. S.-H., JET Contributors, JOREK Team. – *Radiation asymmetry and MHD destabilization after impurity Shattered Pellet Injection.* – Nuclear Fusion 61, 026015 (2021). arXiv:2009.02856
- Nardon E., Hu D., Hoelzl M., Bonfiglio D. – *Fast plasma dilution in ITER with pure Deuterium Shattered Pellet Injection.* – Nuclear Fusion 60, 126040 (2020). arXiv:2006.16020.
- Cathey Cevallos A., Hoelzl M., Lackner K., Huijsmans G.T.A., Dunne M.G., Wolfrum E., Pamela S.J.P., Orain F., Günter S., the JOREK Team, the ASDEX Upgrade Team, and the EUROfusion MST1 Team. – *Non-linear magnetohydrodynamic simulations of type I edge localized mode cycles in tokamak plasmas and their underlying triggering mechanism.* – Nuclear Fusion 60, 124007 (2020). arXiv:2007.09997
- Hoelzl M., Hu D., Nardon E., Huijsmans G.T.A., JOREK Team, ASDEX Upgrade Team. – *First predictive simulations for deuterium shattered pellet injection in ASDEX Upgrade.* – Physics of Plasmas 27, 022510 (2020). arXiv:1910.06095.
- Nikulsin N., Hoelzl M., Zocco A., Lackner K., Günter S. – *Reduced and full MHD formulations for stellarator geometries.* – Physics of Plasmas 26, 102109 (2019). arXiv:1907.12486.
- Bandaru V., Hoelzl M., Artola F.J., Papp G., Huijsmans G.T.A. – *Simulating the non-linear interaction of relativistic electrons and tokamak plasma instabilities: Implementation and validation of a fluid model.* – Physical Review E 99, 063317 (2019). arXiv:1906.12137
- van Vugt D.C., Huijsmans G.T.A., Hoelzl M., Loarte A., Lopes Cardozo N.J. – *Kinetic modelling of ELM-induced W transport in ASDEX Upgrade.* – Physics of Plasmas 26, 042508 (2019)
- Orain F., Hoelzl M., Mink F., Willensdorfer M., Dunne M., Viezzer E., Becoulet M., Huijsmans G., Pamela S., Suttrop W., Günter S., Lackner K., ASDEX Upgrade Team, EUROfusion MST1 Team. – *Non-linear modeling of the threshold between ELM mitigation and ELM suppression by resonant magnetic perturbations in ASDEX Upgrade* – Physics of Plasmas 26, 042503 (2019). arXiv:1902.00398
- Meshcheriakov D., Hoelzl M., Igochine V., Fietz S., Orain F., Huijsmans G.T.A., Maraschek M., Dunne M., McDermott R., Zohm H., Lackner K., Günter S., ASDEX Upgrade Team, EUROfusion MST1 Team. – *Numerical study of tearing mode seeding in tokamak X-point plasma* – Physics of Plasmas 26, 042504 (2019). arXiv:1904.07542
- Artola F.J., Huijsmans G.T.A., Hoelzl M., Beyer P., Loarte A., Gribov Y. – *Non-linear magnetohydrodynamic simulations of Edge Localised Modes triggering via vertical oscillations.* – Nuclear Fusion 58, 096018 (2018).
- Hoelzl M., Huijsmans G.T.A., Orain F., Artola F.J., Pamela S., Becoulet M., van Vugt D., Liu F., Futatani S., Lessig A., Wolfrum E., Mink F., Trier E., Dunne M., Viezzer E., Eich T., Vanovac B., Frassinetti L., Guenter S., Lackner K., Krebs I., ASDEX Upgrade Team, EUROfusion MST1 Team – *Insights into type-I ELMs and ELM control methods from JOREK MHD simulations.* – Contributions to Plasma Physics 58, 518 (2018).
- Mink F., Hoelzl M., Wolfrum E., Orain F., Dunne M., Lessig A., Pamela S., Manz P., Maraschek M., Huijsmans G.T.A., Becoulet M., Laggner F.M., Cavedon M., Lackner K., Guenter S., Stroth U. – *Nonlinear*

*coupling induced toroidal structure of edge localized modes.* – Nuclear Fusion 58, 026011 (2018).

- Nardon E., Fil A., Hoelzl M., Huijsmans G., JET Contributors. – *Progress in understanding disruptions triggered by massive gas injection via 3D non-linear MHD modelling with JOREK.* – Plasma Physics and Controlled Fusion 59, 014006 (10/2016).
- Orain F., Hoelzl M., Viezzer E., Dunne M., Willensdorfer M., Suttrop W., Strumberger E., Guenter S., Lessig A., ASDEX Upgrade Team, Becoulet M., Huijsmans G.T.A., Morales J., Kirk A., Pamela S., Cahyna P., EUROfusion MST1 Team. – *Non-linear modeling of the plasma response to RMPs in ASDEX Upgrade.* – Nuclear Fusion 57, 022013 (09/2016). arxiv:1602.07564
- Franck E., Hoelzl M., Lessig A., Sonnendrücker E. – *Energy conservation and numerical stability for the reduced MHD models of the non-linear JOREK code.* – ESAIM: Mathematical Modelling and Numerical Analysis 49, 1331 (08/2015). arxiv:1408.2099
- Hoelzl M., Huijsmans G.T.A., Merkel P., Atanasiu C., Lackner K., Nardon E., Aleynikova K., Liu F., Strumberger E., McAdams R., Chapman I., Fil A. – *Non-Linear Simulations of MHD Instabilities in Tokamaks Including Eddy Current Effects and Perspectives for the Extension to Halo Currents.* – Journal of Physics: Conference Series 561, 012011 (12/2014). arxiv:1408.6379
- Krebs I., Hoelzl M., Lackner K., Günter S. – *Nonlinear excitation of low-n harmonics in reduced MHD simulations of edge-localized modes.* – Physics of Plasmas, 20, 082506 (08/2013). arxiv:1305.3727
- Hoelzl M., Merkel. P., Huysmans G.T.A., Nardon E., McAdams R., Chapman I. – *Coupling the JOREK and STARWALL Codes for Non-linear Resistive-wall Simulations.* – Journal of Physics: Conference Series, 401, 012010 (12/2012). arxiv:1206.2748
- Hoelzl M., Günter S., Wenninger R.P., Mueller W.-C., Huysmans G.T.A., Lackner K., Krebs I., ASDEX Upgrade Team. – *Reduced-MHD Simulations of Toroidally and Poloidally Localized ELMs.* – Physics of Plasmas, 19, 082505 (08/2012). arxiv:1201.5765
- Hoelzl M., Günter S., Classen I., Yu Q., the TEXTOR Team, Delabie E. – *Determination of the heat diffusion anisotropy by comparing measured and simulated electron temperature profiles across magnetic islands.* – Nuclear Fusion, 49, 115009 (09/2009).

## Conference and Workshop Contributions

Full list at matthias-hoelzl.org/conferences.html

- **Oral** Hoelzl M., Cathey-Cevallos A., Futatani S., Huijsmans G.T.A., Orain F., Dunne M., Pamela S.J.P., Becoulet M., Artola F.J., van Vugt D.C., Smith S.F., Schwarz N., Liu F., Korving S.Q., Gruca M., Günter S., Lackner K., Wolfrum E., Viezzer E., Lang P.T., JOREK Team, ASDEX Upgrade Team, EUROfusion MST1 Team. – *Simulations of edge localized mode dynamics and their control.* – 28th IAEA Fusion Energy Conference (FEC 2020), Nice, France (12/5/2021).
- **Invited Oral** Hoelzl M. – *3D non-linear simulations of disruptions and edge localized modes.* – Annual Meeting of the Max Planck Princeton Center for Fusion and Astro Plasma Physics (22/1/2021). Remote meeting.
- **Oral** Hoelzl M., Artola F.J., Bandaru V.K., Nardon E., Wieschollek F., Hu D., Bonfiglio D., Sommariva C., Krebs I., van Vugt D., Meshcheriakov D., Huijsmans G.T.A., JOREK Team – *Disruption oriented research with the JOREK code.* – 8th Runaway Electron Modelling (REM) meeting, Gothenburg, Sweden (1/2020).
- **Invited Oral** Hoelzl M. – *Edge localized modes and disruptions – Insights into large-scale plasma instabilities from non-linear MHD simulations.* – Institute Colloquium, Max Planck Institute for Plasma Physics, Garching, Germany (12/2018).
- **Invited Oral** Hoelzl M., G.T.A. Huijsmans, F. Orain, F.J. Artola, S. Pamela, F. Liu,, D. van Vugt, S. Futatani, M. Becoulet, A. Cathey, K. Lackner, S. Günter, et al – *Simulating tokamak edge instabilities: advances and challenges.* – 45th European Physical Society Conference on Plasma Physics (EPS), Prague, Czech Republic, I5.J601 [abstract] (7/2018).
- **Invited Oral** Hoelzl M., Huijsmans G.T.A., Orain F., Artola F.J., Liu F., Futatani S., van Vugt D., Wolfrum E., Mink F., Trier E., Dunne M., Vanovac B., Viezzer E., Lessig A., Becoulet M., Pamela S., Guenter S., Lackner K., Krebs I., Wenninger R., Eich T., Frassinetti L., JOREK Team, ASDEX Upgrade Team, EUROfusion MST1 Team. – *What non-linear simulations can teach about ELM physics.* – 16th International Workshop on Plasma Edge Theory in Fusion Devices, Marseille, France, I3 (09/2017).

## Teaching and Supervision

Full list at matthias-hoelzl.org/teaching.html

- Supervison of various Postdoctoral Researchers, PhD, master and bachelor students, as well as many working students. Substitutions for plasma physics lectures at Technical University Munich.

## Commitments

- Since 2018: Chair of High Performance Computing Committee at Max Planck Institute for Plasma Physics
- 2018–2020: Member of IT coordination committee at Max Planck Institute for Plasma Physics
- 2018: Member of EUROfusion Ad Hoc Group on *Disruption and Run-away Electron Research & Development Strategy in view of preparing ITER and DEMO operation*
- 2014 to 2018: Member of scientists' representative council of Max Planck Institute for Plasma Physics
- Since 2013: Coordinator of JOREK code development, organizer of JOREK remote seminar, administrator of JOREK website and collaboration platform
- Referee for: Springer Nature Publishing, Physical Review Letters, Computer Physics Communications, Nuclear Fusion, Physics of Plasmas, Plasma Physics and Controlled Fusion, Physica Scripta, United States Department of Energy, L'Agence nationale de la recherche, Netherlands Organisation for Scientific Research, etc. — *Some of the reviews are listed at Publons*.