# Joonas Nättilä

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Sex: Male
Born: June 25th, 1989, Tornio, Finland
Nationality: Finnish citizen
Languages: Finnish (native), English, Swedish

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## Research interests

*High-energy astrophysics*: accretion (accretion disks); compact objects (neutron stars, black holes)
*Plasma physics*: collisionless plasma dynamics; turbulence; particle acceleration
*Computer sciences*: high-performance computing; parallelization paradigms; machine learning; Julia language
*Statistics*: Bayesian inference; Monte Carlo methods
*Mathematics*: cellular automata models

## Employment

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| 2021–2023 | **Flatiron Research Fellow**, Flatiron Institute's Center for Computational Astrophysics, New York, USA. |
| 2019–2021 | **Postdoctoral Research Scientist**, Columbia University, New York, USA. |
| 2018–2019 | **Nordita Fellow**, Nordita (Nordic Institute for Theoretical Physics), Stockholm, Sweden. |

## Education

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| 2014–2017 | **Ph.D. in Astrophysics (with honours)**, University of Turku, Finland.<br>Supervisor: Prof. Juri Poutanen, Director of Tuorla Observatory.<br>Title: X-ray bursts as a tool to constrain the equation of state of the ultra-dense matter inside neutron stars |
| 2012–2013 | **M.Sc. in Astronomy**, University of Oulu, Finland. |
| 2008–2012 | **B.Sc. in Physics**, University of Oulu, Finland. |

## Awards & Recognitions

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| 2019 | Joint Princeton/Flatiron Postdoctoral Research Fellowship, Princeton University (*Declined*) |
| 2018 | Turku Finnish University Society Prize for best doctoral dissertation |
| 2018 | Väisälä Prize 2018: Prize for outstanding thesis in Astronomy |
| 2018 | PCS Best Doctoral Thesis of 2017 Prize |
| 2016 | Nordita Visiting Ph.D. Fellow |

## Teaching

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| 2019 | **Visiting Lecturer, Computational fluid dynamics course**, Columbia University, USA.<br>Visiting lecturer on "Collisionless plasma simulations". |
| 2015—2019<br>(5 times) | **Lecturer, High Performance Computing Summer School**, CSC, Finland.<br>Lecturer & tutor for Finnish IT Center for Science HPC Summer School. |
| 2018, 2019<br>(2 times) | **Lecturer, Introduction to Julia**, CSC, Finland.<br>Lecturer for an introductory course on the Julia programming language. |
| 2015—2017<br>(3 times) | **Lecturer, Software tools in Physics**, University of Turku, Finland.<br>Lecturer of the "Introduction to Unix" section of the course (3 ECTS). |

In addition, teaching assistant in **Optics** (2016; 6 ECTS) in Univ. Turku, and **Thermophysics** (3 times, 2011—2013; 6 ECTS), **Electricity and Magnetism** (2012; 4 ECTS), **Laboratory Exercises in Physics 1** (2 times, 2011—2012; 3 ECTS), **Mathematics of Physics** (2011; 6 ECTS), and **Waveforms and Optics** (2 times, 2011; 6 ECTS) in Univ. Oulu.

January 2, 2021

# Mentoring & Supervision

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| 2017–2020 | **Tuomo Salmi**, PhD. student, University of Turku, Finland.<br>PhD. co-supervisor: Neutron star mass and radius constraints from pulse profile modeling. |
| 2019 | **John Hope**, MSc. student, University of Bath, UK.<br>M.Sc. thesis supervisor: PIC simulations of relativistic collisionless shocks across different magnetizations. |
| 2015–2017 | **Jere Kuuttila**, co-supervisor for M.Sc. thesis, University of Turku, Finland. |
| 2015–2016 | **Tuomo Salmi**, co-supervisor for M.Sc. thesis, University of Turku, Finland. |
| 2014–2015 | **Jere Kuuttila**, co-supervisor for B.Sc. thesis, University of Turku, Finland. |

In addition, Nordita host for visiting PhD. students: **M. Bussov**, Dec. 2019; **K. Smedt**, Nov. 2019; **T. Salmi**, May 2019.

# Presentations & Talks

Most recent ones include:

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| 2020 | ***Invited*** **IAS Coffee talk**, Princeton, USA. |
| 2020 | ***Colloquium:*** **Kumpula Colloquium**, Helsinki, Finland. |
| 2020 | ***Invited:*** **Nordita Dynamo Series**, Stockholm, Sweden. |
| 2020 | **Nordita Astro group meeting**, Stockholm, Sweden. |
| 2020 | ***Invited:*** **St. Louis neutron star meeting**, St. Louis, USA. |
| 2020 | **CCA compact object meeting**, New York, USA. |
| 2019 | **Extreme Objects Meeting**, Stockholm, Sweden. |
| 2019 | **KITP conference on Multiscale modeling of Plasmas**, Santa Barbara, USA. |
| 2019 | ***Invited:*** **Bursting the Bubble**, Lorentz center, Leiden, Netherlands. |
| 2019 | ***Invited:*** **Astro Colloquium**, University of Tübingen, Tübingen, Germany. |

In total 1 colloquium, 13 invited, 24 contributed talks.

# Funding

## Research

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| 2020 | $\sim$ **60 000 eur Wenner-Gren grant Co-I**: Postdoc grant for Surajit Mondal<br>Reconnection, Radio observations, and switchbacks. |
| 2016 | $\sim$ **2 000 eur Magnus Ehrnrooth Foundation** Travel grant |
| 2015–2017 | **UTUGS Physical and Chemical Sciences funded 3yr. Ph.D. scholarship**<br>Constraining neutron star mass and radius. |
| 2015–2016 | **23 000 eur Väisälä Foundation grant**<br>Magnetar atmosphere models (*Declined*) |
| 2014–2015 | **23 000 eur Väisälä Foundation grant**<br>Magnetar atmosphere models: breaking the barrier between observations and theory |

+ Some smaller travel grants (in total $\sim$ 10k eur).

## Supercomputer time

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| 2021 | $\sim$ **22M CPUh SNIC/Beskow**, **Co-PI**: Astrophysical turbulence and dynamo action |
| 2020 | $\sim$ **22M CPUh SNIC/Beskow/Kebnekaise**, **Co-PI**: Astrophysical turbulence and dynamo action |
| 2019 | $\sim$ **22M CPUh SNIC/Beskow/Kebnekaise**, **Co-PI**: Astrophysical turbulence and dynamo action |
| 2018 | $\sim$ **60k CPUh SNIC/Kebnekaise**, **PI**: Relativistic plasma in silico (testing of Runko). |

# Professional Societies and Services

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| 2019– | Member of Young Academy Finland (under Finnish Academy of Sciences and Letters) |
| 2018– | IAU Junior member |
| 2017 | Organizer & Convener for CompCoffee meetings (weekly meetings to discuss computational problems) |
| 2016– | eXTP Dense Matter science working group |
| 2015–2018 | ESA XIPE satellite Science Team (SWG2.2 Accreting Millisecond Pulsars) |
| 2014– | Member of organizing committee for CSC HPC Summer Schools |
| 2013–2019 | Member of JuliaLang organization (Open source community for Julia programming language) |
| 2012– | Member of Finnish Astronomical Society |

In addition, referee for ApJL, MNRAS, A&A, ApJ, Phys. Rev. D., European Physical Journal A, and Universe.

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## Conference organization

2017 **Nordita Workshop: Exascale thinking of particle energization problems**, Stockholm, Sweden.
Member of the scientific and local organizing committee.

2015 **Workshop on Relativistic Astrophysics**, Kavalto, Finland.
Member of the local organizing committee.

2015 **PCS Annual Seminar day**, University of Turku, Finland.
Chairman & member of the organizing committee.

## Public outreach

My research has been presented in various media:

2020 **Published text on Finnish science magazine Q&A section**
"How can neutron stars have a magnetic field?" Tähdet & Avaruus Sep. 2020 issue.

2020 **Published text on Finnish science magazine Q&A section**
"What happens to neutron star matter outside the star?" Tähdet & Avaruus Oct. 2020 issue.

2020 **Meet the scientist**: Educational science video on "Gravitation".
Popular science video targeted for high school students, youtube.com/watch?v=Ch38VpF341I

2019 **Academy Club for Young Scientist**: Public science talk.
Astrophysical turbulence: from stirring coffee to mixing galaxies; youtube.com/watch?v=W7ljVlSEAX4

2019—2020 **On the possibility of quark matter cores in neutron star** (Annala et al. 2020)
Incl.: Astrobites, Universe Today, Physics World, Wikipedia on QCD matter, Tähdet & Avaruus 4/2019

2019 **Twitter AMA on scientists abroad**
In part of TimeoutDialogue/Erätauko society.

2018 **Personal profile** on Tähdet & Avaruus Finnish science magazine.
Tähdet & Avaruus Feb 2018 issue.

2017 **Groundbreaking new neutron star radius measurement** (Nättilä et al. 2017)
Incl.: Cosmos 27.11.2017, Phys.org. Tähdet & Avaruus (25.11.2017), Turkulainen (10.11.2017), Turun Sanomat (10.11.2017), Aamuset (8.12.2017), Tekniikka & Talous (8.12.2017), Verkkouutiset (8.12.2017)

2016 **Detection of burning ashes from neutron stars** (Kajava, Nättilä, et al 2017)
Tiedetuubi.fi (30.11.2016)

# Publications — Joonas Nättilä

25 refereed publications; incl. *Nature Physics* (1), *PRL* (1), *ApJ* (4), *A&A* (11), *MNRAS* (6).
In total 629 citations since 2014; h-index 12, g-index 24, i10-index 13 (ADS).

## Peer-reviewed scientific articles


[25] **J. Nättilä** and A. M. Beloborodov. Radiative turbulent flares in magnetically-dominated plasmas. *arXiv e-prints*, page arXiv:2012.03043, December 2020, [arXiv:2012.03043].

[24] M. Al-Mamun, A. W. Steiner, **J. Nättilä**, J. Lange, R. O'Shaughnessy, I. Tews, S. Gandolfi, C. Heinke, and S. Han. Combining Electromagnetic and Gravitational-Wave Constraints on Neutron-Star Masses and Radii. *Phys. Rev. Lett.*, page arXiv:2008.12817, August 2020, [arXiv:2008.12817].

[23] V. Loktev, T. Salmi, **J. Nättilä**, and J. Poutanen. Oblate Schwarzschild approximation for polarized radiation from rapidly rotating neutron stars. *A&A*, 643:A84, November 2020, [arXiv:2009.08852].

[22] T. Salmi, V. F. Suleimanov, **J. Nättilä**, and J. Poutanen. Magnetospheric return-current-heated atmospheres of rotation-powered millisecond pulsars. *A&A*, 641:A15, September 2020, [arXiv:2002.11427].

[21] E. Annala, T. Gorda, A. Kurkela, **J. Nättilä**, and A. Vuorinen. Evidence for quark-matter cores in massive neutron stars. *Nature Physics*, 16(9):907–910, June 2020, [arXiv:1903.09121].

[20] P Abolmasov, **J. Nättilä**, and J Poutanen. Kilohertz quasi-periodic oscillations from neutron star spreading layers. *A&A*, 638:A142, June 2020, [arXiv:1910.09906].

[19] A. Veledina, **J. Nättilä**, and A. M. Beloborodov. Pulsar Wind-heated Accretion Disk and the Origin of Modes in Transitional Millisecond Pulsar PSR J1023+0038. *ApJ*, 884(2):144, October 2019, [arXiv:1906.02519].

[18] F. Nauman and **J. Nättilä**. Exploring helical dynamos with machine learning: Regularized linear regression outperforms ensemble methods. *A&A*, 629:A89, September 2019.

[17] **J. Nättilä**. Runko: Modern multi-physics toolbox for simulating plasma. *arXiv e-prints*, page arXiv:1906.06306, June 2019, [arXiv:1906.06306].

[16] J. J. M. in't Zand, E. Bozzo, J. Qu, X.-D. Li, L. Amati, Y. Chen, I. Donnarumma, V. Doroshenko, S. A. Drake, and et al. (incl. **J. Nättilä**). Observatory science with eXTP. *Science China Physics, Mechanics, and Astronomy*, 62:29506, February 2019.

[15] A. L. Watts, W. Yu, J. Poutanen, S. Zhang, S. Bhattacharyya, S. Bogdanov, L. Ji, A. Patruno, T. E. Riley, and et al. (incl. **J. Nättilä**). Dense matter with eXTP. *Science China Physics, Mechanics, and Astronomy*, 62:29503, February 2019.

[14] Z. Li, V. F. Suleimanov, J. Poutanen, T. Salmi, M. Falanga, **J. Nättilä**, and R. Xu. Evidence for the Photoionization Absorption Edge in a Photospheric Radius Expansion X-Ray Burst from GRS 1747−312 in Terzan 6. *ApJ*, 866:53, October 2018, [arXiv:1809.00098].

[13] T. Salmi, **J. Nättilä**, and J. Poutanen. Bayesian parameter constraints for neutron star masses and radii using X-ray timing observations of accretion-powered millisecond pulsars. *A&A*, 618:A161, October 2018, [arXiv:1805.01149].

[12] P. Pihajoki, M. Mannerkoski, **J. Nättilä**, and P. H. Johansson. General purpose ray-tracing and polarized radiative transfer in General Relativity. *ApJ*, 863:8, August 2018, [arXiv:1804.04670].

[11] **J. Nättilä** and P. Pihajoki. Radiation from rapidly rotating oblate neutron stars. *A&A*, 615:A50, July 2018, [arXiv:1709.07292].

[10] **J. Nättilä**, M. C. Miller, A. W. Steiner, J. J. E. Kajava, V. F. Suleimanov, and J. Poutanen. Neutron star mass and radius measurements from atmospheric model fits to X-ray burst cooling tail spectra. *A&A*, 608:A31, December 2017, [arXiv:1709.09120].

[9] V. F. Suleimanov, J. J. E. Kajava, S. V. Molkov, **J. Nättilä**, A. A. Lutovinov, K. Werner, and J. Poutanen. Basic parameters of the helium-accreting X-ray bursting neutron star in 4U 1820-30. *MNRAS*, 472:3905–3913, December 2017, [arXiv:1708.09168].

[8] J. J. E. Kajava, K. I. I. Koljonen, **J. Nättilä**, V. Suleimanov, and J. Poutanen. Variable spreading layer in 4U 1608-52 during thermonuclear X-ray bursts in the soft state. *MNRAS*, 472:78–89, November 2017, [arXiv:1707.09479].

[7] J. Kuuttila, J. J. E. Kajava, **J. Nättilä**, S. E. Motta, C. Sánchez-Fernández, E. Kuulkers, A. Cumming, and J. Poutanen. Flux decay during thermonuclear X-ray bursts analysed with the dynamic power-law index method. *A&A*, 604:A77, August 2017, [arXiv:1705.05653].

[6] V. F. Suleimanov, J. Poutanen, **J. Nättilä**, J. J. E. Kajava, M. G. Revnivtsev, and K. Werner. The direct cooling tail method for X-ray burst analysis to constrain neutron star masses and radii. *MNRAS*, 466:906–913, April 2017, [arXiv:1611.09885].

[5] J. J. E. Kajava, **J. Nättilä**, J. Poutanen, A. Cumming, V. Suleimanov, and E. Kuulkers. Detection of burning ashes from thermonuclear X-ray bursts. *MNRAS*, 464:L6–L10, January 2017, [arXiv:1608.06801].

[4] **J. Nättilä**, A. W. Steiner, J. J. E. Kajava, V. F. Suleimanov, and J. Poutanen. Equation of state constraints for the cold dense matter inside neutron stars using the cooling tail method. *A&A*, 591:A25, June 2016, [arXiv:1509.06561].

[3] **J. Nättilä**, V. F. Suleimanov, J. J. E. Kajava, and J. Poutanen. Models of neutron star atmospheres enriched with nuclear burning ashes. *A&A*, 581:A83, September 2015, [arXiv:1507.01525].

[2] J. J. E. Kajava, **J. Nättilä**, O.-M. Latvala, M. Pursiainen, J. Poutanen, V. F. Suleimanov, M. G. Revnivtsev, E. Kuulkers, and D. K. Galloway. The influence of accretion geometry on the spectral evolution during thermonuclear (type I) X-ray bursts. *MNRAS*, 445:4218–4234, December 2014, [arXiv:1406.0322].

[1] J. Poutanen, **J. Nättilä**, J. J. E. Kajava, O.-M. Latvala, D. K. Galloway, E. Kuulkers, and V. F. Suleimanov. The effect of accretion on the measurement of neutron star mass and radius in the low-mass X-ray binary 4U 1608-52. *MNRAS*, 442:3777–3790, August 2014, [arXiv:1405.2663].

## Proceedings

[2] E. Annala, T. Gorda, A. Kurkela, **J. Nättilä**, and A. Vuorinen. Constraining the properties of neutron-star matter with observations. In *12th INTEGRAL Conference*, Geneva, Switzerland, 11-15 February 2019 [arXiv:1904.01354].

[1] P. Soffitta, R. Bellazzini, E. Bozzo, V. Burwitz, A. Castro-Tirado, E. Costa, T. Courvoisier, H. Feng, S. Gburek, R. Goosmann, and et al. (incl. **J. Nättilä** ) XIPE: the x-ray imaging polarimetry explorer. In *Space Telescopes and Instrumentation 2016: Ultraviolet to Gamma Ray*, volume 9905 of *Proc. SPIE*, page 990515, July 2016. doi.org/10.1117/12.2233046.

## Theses

[3] **J. Nättilä**. X-ray bursts as a tool to constrain the equation of state of the ultra-dense matter inside neutron stars. PhD thesis, University of Turku, Finland, 2017. ISBN:978-951-29-7057-5.

[2] **J. Nättilä**. Mass and radius constraints for neutron stars using the cooling tail method. Master's thesis, University of Oulu, Finland, 2013. oulu-201312041966.

[1] **J. Nättilä**. Spectral analysis of X-ray bursts from neutron stars: IGR J1747–2721 (*Neutronitähtien röntgenpurkaukset ja niiden spektrianalyysi: IGR J1747–2721*). Bachelor's thesis, University of Oulu, Finland, 2012.

## Open source software

[6] **Runko**, Modern C++14/PYTHON3 toolbox for kinetic plasma simulations. https://github.com/natj/runko

[5] **CORGI**, C++14 grid infrastructure for massively parallel multi-physics simulations. https://github.com/natj/corgi

[4] **mpi4cpp**, User-friendly C++14 MPI headers with template metaprogramming. https://github.com/natj/mpi4cpp

[3] **Bender, ray tracing code**, General relativistic ray tracing code for computing radiation from rapidly rotating oblate neutron stars in JULIA/PYTHON3. https://github.com/natj/bender

[2] **Hydro, modular 2D hydrodynamical code** with unsplitted HLLC Rieman solver, second order Runge-Kutta time-stepping, and linear piecewise reconstruction written in pure JULIA. https://github.com/natj/hydro

[1] **CellularAutomata.jl**, JULIA library for 1/2D elementary and totalistic Cellular automata modeling. https://github.com/natj/CellularAutomata.jl

+ Smaller libraries and software available at https://github.com/natj.