

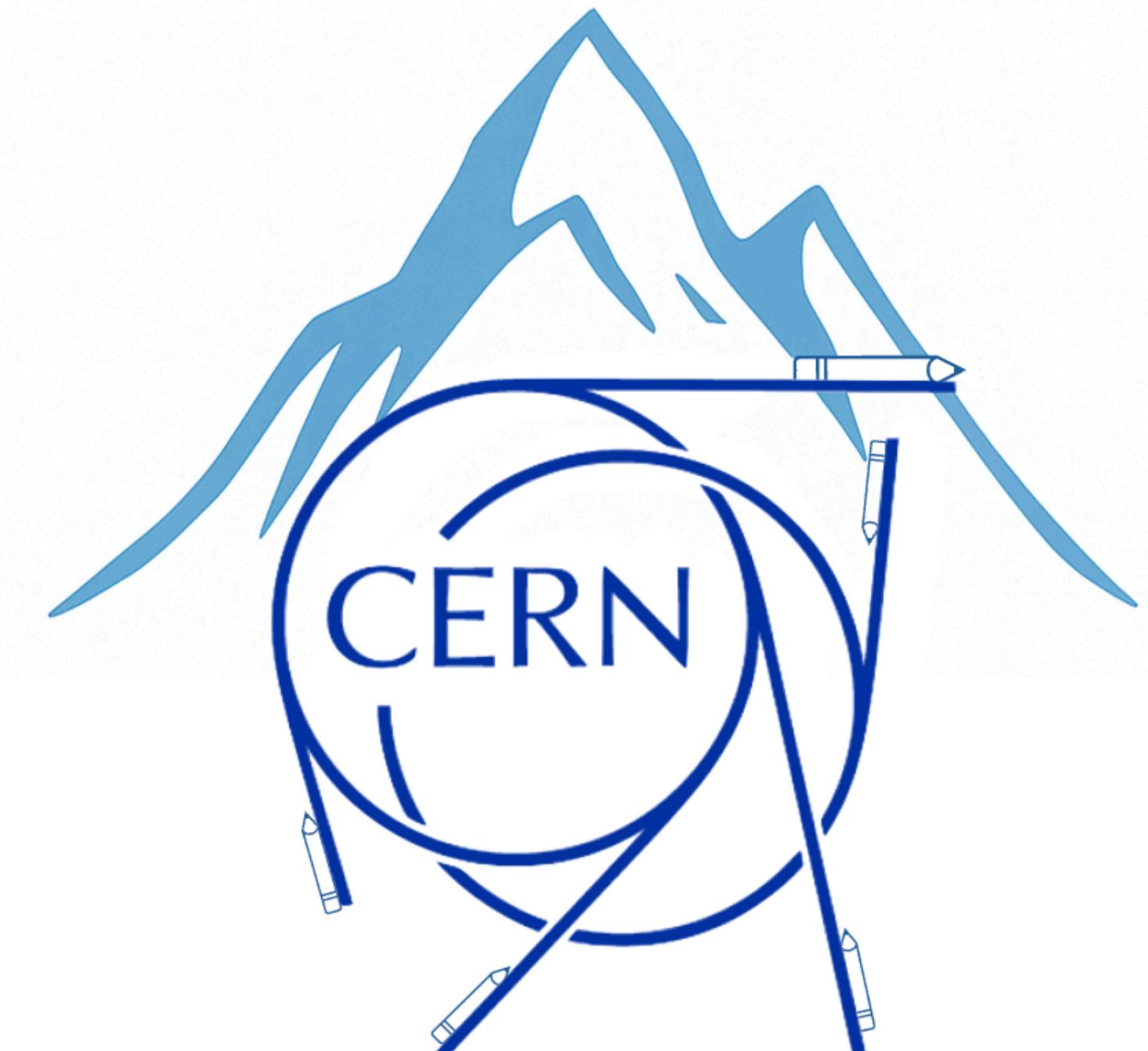
# *1st Pencil Code school on early Universe physics and gravitational waves*

**CERN, 20-24 October 2025**

**Organizers:**

***Alberto Roper Pol (University of Geneva)***  
***Antonino Midiri (University of Geneva)***

**Accelerating the  
Pencil Code**



**Pencil Code User Meeting**  
October 2025 - CERN (Switzerland)

# Lecturers



Axel Brandenburg  
(Nordita)



Philippe Bourdin  
(University of Graz)



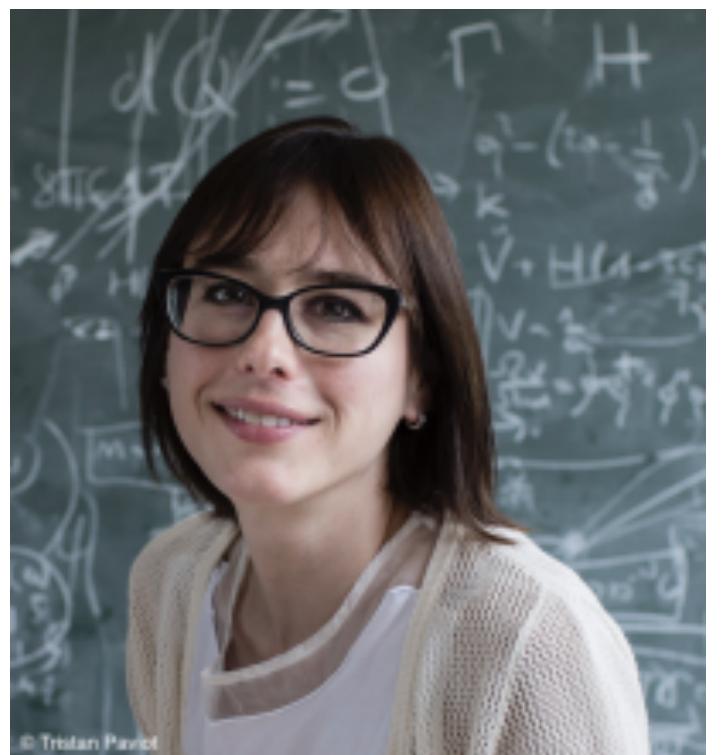
Simon Candelaresi  
(University of Augsburg)  
online



Matthias Rheinhardt  
(Aalto University)



Alberto Roper Pol  
(University of Geneva)



Chiara Caprini  
(University of Geneva/  
CERN)



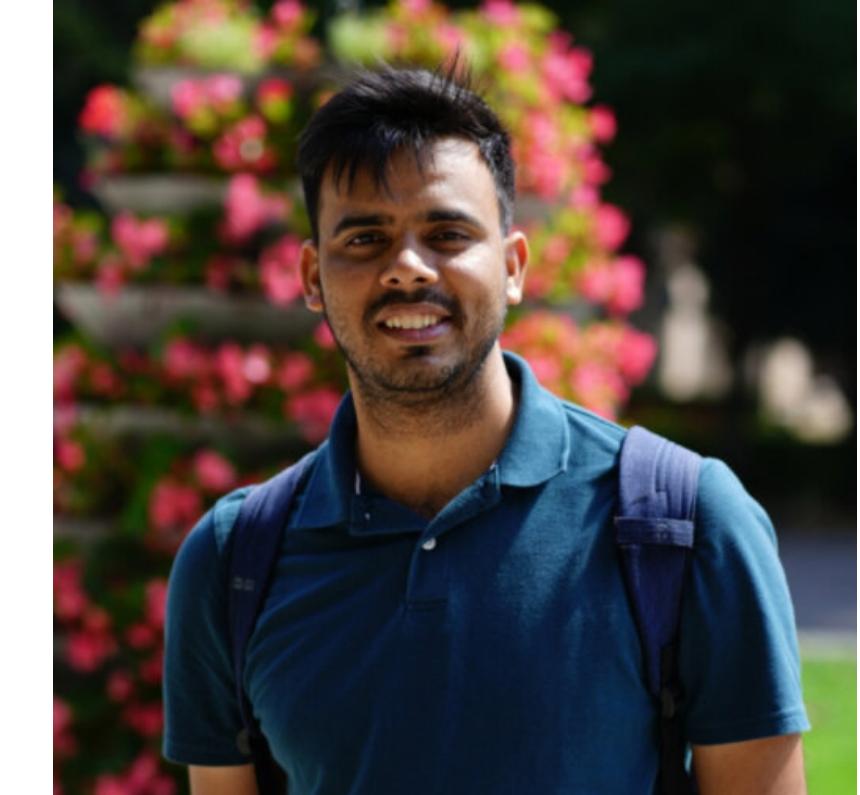
Deepen Garg  
(University of Bonn)



Antonino Midiri  
(University of Geneva)



Isak Stomberg  
(IFIC Valencia)



Ramkishor Sharma  
(University of Hyderabad)  
online

# **Lectures on Pencil Code:**

- Basics of Pencil Code (P. Bourdin). Mon 11:30am
- Numerical schemes for differential equations (P. Bourdin & A. Midiri). Tue 9:30am
- Data handling and I/O approaches (P. Bourdin). Tue 11:30am
- Power spectra (I. Stomberg & S. Candelaresi). Tue 12:30pm
- Post-processing and visualization (A. Brandenburg, P. Bourdin, S. Candelaresi). Tue 2pm
- Parallelization on CPUs (M. Rheinhardt). Wed 9:30am
- Subversioning and autotests (A. Roper Pol). Wed 10:30am
- Acceleration on GPUs (M. Rheinhardt). Wed 12pm



Axel Brandenburg  
(Nordita)



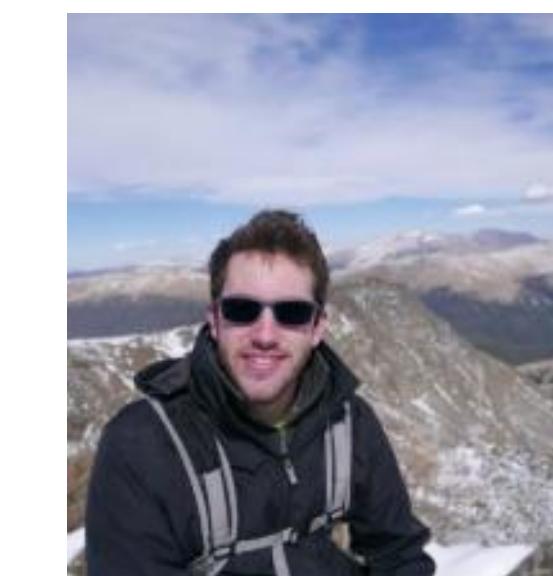
Philippe Bourdin  
(University of Graz)



Simon Candelaresi  
(University of Augsburg)  
online



Matthias Rheinhardt  
(Aalto University)



Alberto Roper Pol  
(University of Geneva)



Antonino Midiri  
(University of Geneva)



Isak Stomberg  
(IFIC Valencia)

## **Hands-on sessions:**

- Getting familiar with the code. Mon 3pm
- Sound and Alfvén waves. Mon 4:30pm
- Forced helical turbulence. Wed 4pm
- Decaying MHD turbulence. Fri 9:30am
- Gravitational waves. Fri 2pm
- Open sessions. Wed 4pm & Fri 4pm



Deepen Garg  
(University of Bonn)



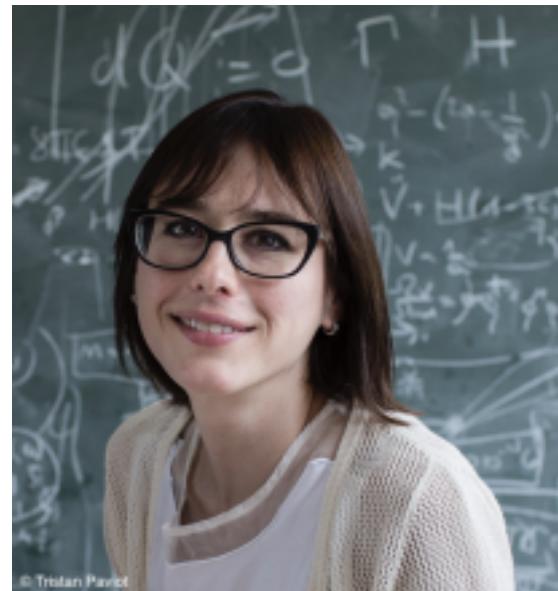
Antonino Midiri  
(University of Geneva)



Alberto Roper Pol  
(University of Geneva)

## ***Applications to early Universe:***

- Magnetohydrodynamics in the early Universe (A. Roper Pol & A. Brandenburg). Thu 9:30am
- Primordial magnetic fields (A. Roper Pol). Thu 11:30am
- Chiral MHD (D. Garg). Thu 12:30pm
- Gravitational waves (C. Caprini). Thu 2pm
- Inflation (R. Sharma). Thu 4pm
- First-order phase transitions (A. Midiri & I. Stomberg). Fri 11:30am
- CosmoGW (A. Roper Pol). Fri 2pm



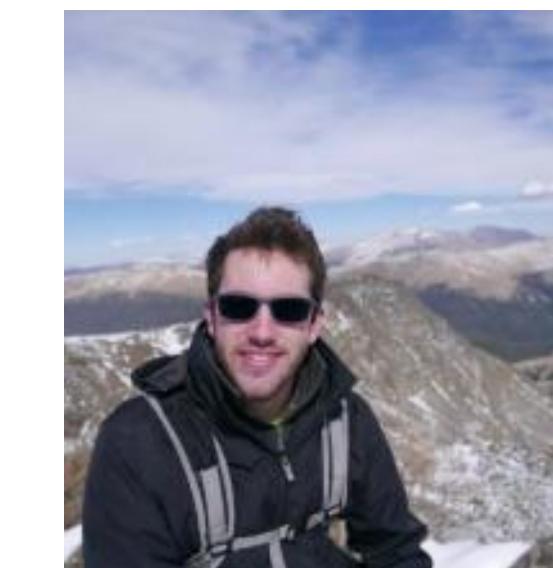
Chiara Caprini  
(University of Geneva/  
CERN)



Deepen Garg  
(University of Bonn)



Axel Brandenburg  
(Nordita)



Alberto Roper Pol  
(University of Geneva)



Antonino Midiri  
(University of Geneva)



Ramkishor Sharma  
(University of Hyderabad)  
online



Isak Stomberg  
(IFIC Valencia)

## **Logistics**

- All lectures will be at the CERN theory room 4/3-006 (here!)
- **Coffee breaks** every day at 11am and 3:30pm (exception 4pm today!) at the CERN TH common room (3rd floor)
- During coffee breaks, take only from catering thermos, not capsules (they belong to the TH department!)  
- Lunch at the main cafeteria (on your own)
- **Theory Colloquium on Wednesday at 2pm** by A. Brandenburg “Dynamics versus magnetogenesis: astrophysics versus cosmology”
- **School reception on Wednesday at 7pm**

# Pencil Code

(<https://pencil-code.nordita.org/>)



## The Pencil Code

a high-order finite-difference code for compressible MHD

**Home**

**News**

**Documentation**

**Highlights**

**Samples**

**Autotests**

**Download**

**Meetings**

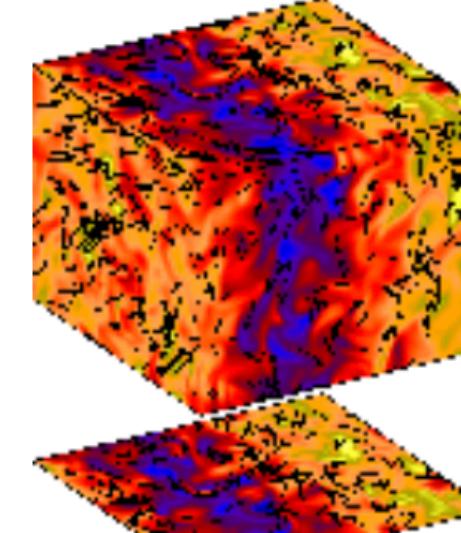
**References**

**Contact**

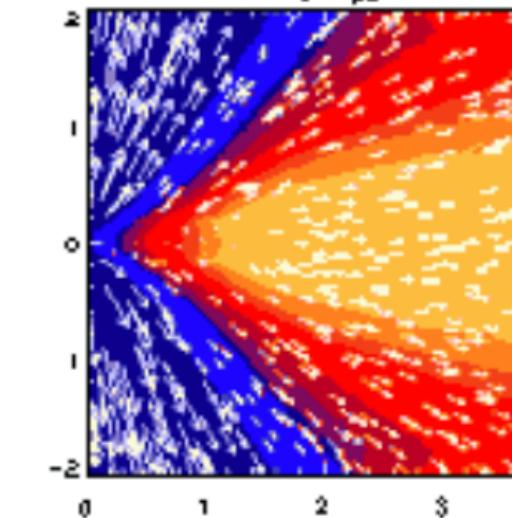
**Latest changes ...**

The **Pencil Code** is a high-order finite-difference code for compressible hydrodynamic flows with magnetic fields. It is highly modular and can easily be adapted to different types of problems. The code runs efficiently under MPI on massively parallel shared- or distributed-memory computers.

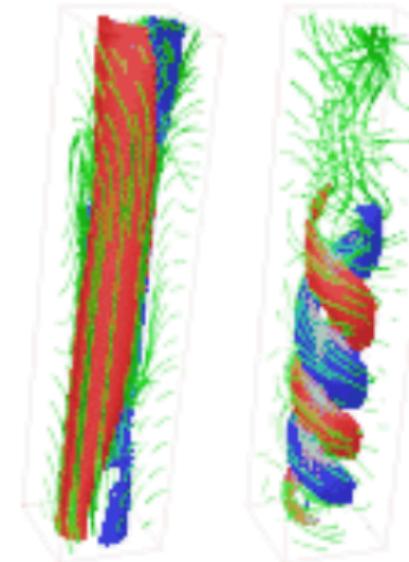
The Pencil Code or equivalent codes have been used for many different applications in a (more or less) astrophysical context. Examples are



*Turbulence simulations*



*Outflows from accretion discs*



*Dynamo experiments*

Available as open source code on <https://github.com/pencil-code/pencil-code/>. It is being updated after each change in the developer's repository, which can be accessed both through svn and git; see <https://pencil-code.org/download.php>.

### Pencil News

Recent news item about the Newsletter, Pencil Code office hours, and the the Pencil Code Steering Committee: [\[more...\]](#)

---

### Get Pencil

There are several ways how to get the code. [\[more...\]](#)

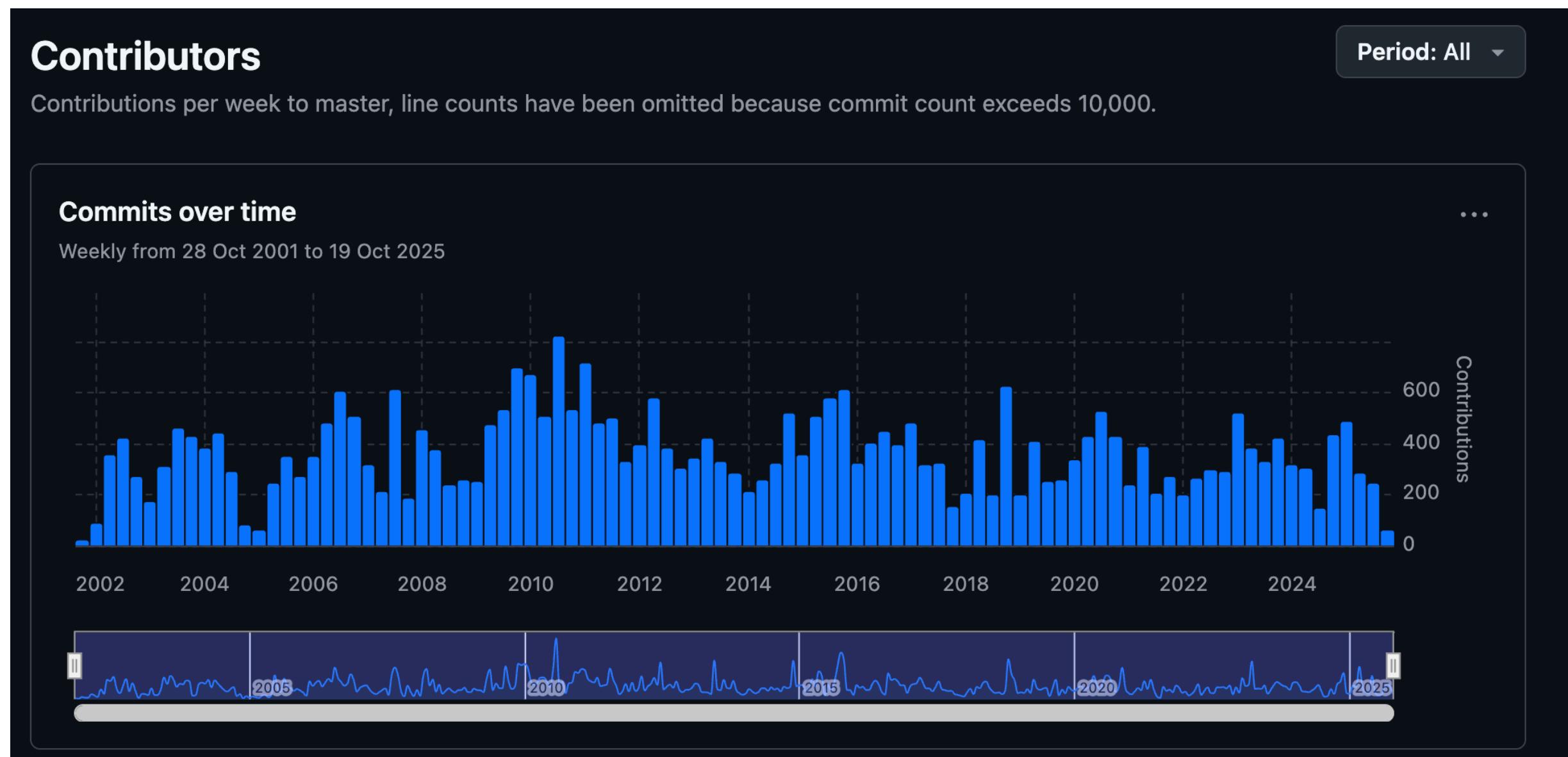
---

### Learn Pencil

Quick start guide for beginners, samples, manual & [\[more...\]](#)

# Pencil Code development

- Collaborative project (96 contributors and 20 code administrators)
- Multiple applications, continuous development of new applications since its beginning in 2001
- Early Universe applications have gained increasing interest in the last 7-8 years since development of gravitational wave module in 2017
- Latest version of the code always available, be responsible and aware of using latest version, especially regarding new applications under development



DOI: [10.21105/joss.02807](https://doi.org/10.21105/joss.02807)  
Software

- [Review](#)
- [Repository](#)
- [Archive](#)

Editor: [Afon Smith](#)

Reviewers:

- [@zingale](#)
- [@rtfisher](#)

Submitted: 17 September 2020  
Published: 21 February 2021

License

Authors of papers retain copyright and release the work under a Creative Commons Attribution 4.0 International License ([CC BY 4.0](#)).

The Pencil Code, a modular MPI code for partial differential equations and particles: multipurpose and multiuser-maintained

The Pencil Code Collaboration<sup>1</sup>, Axel Brandenburg<sup>1, 2, 3</sup>, Anders Johansen<sup>4</sup>, Philippe A. Bourdin<sup>5, 6</sup>, Wolfgang Dobler<sup>7</sup>, Vladimir Lyra<sup>8</sup>, Matthias Reinhardt<sup>9</sup>, Sven Bingert<sup>10</sup>, Nils Erland L. Haugen<sup>11, 12, 1</sup>, Antony Mee<sup>13</sup>, Frederick Gent<sup>9, 14</sup>, Natalia Babkovskia<sup>15</sup>, Chao-Chin Yang<sup>16</sup>, Tobias Heinemann<sup>17</sup>, Boris Dintrans<sup>18</sup>, Dhrubaditya Mitra<sup>1</sup>, Simon Candelaresi<sup>19</sup>, Jörn Warnecke<sup>20</sup>, Petri J. Käpylä<sup>21</sup>, Andreas Schreiber<sup>15</sup>, Piyali Chatterjee<sup>22</sup>, Maarit J. Käpylä<sup>9, 20</sup>, Xiang-Yu Li<sup>1</sup>, Jonas Krüger<sup>11, 12</sup>, Jørgen R. Aarnes<sup>12</sup>, Graeme R. Sarson<sup>14</sup>, Jeffrey S. Oishi<sup>23</sup>, Jennifer Schober<sup>24</sup>, Raphaël Plasson<sup>25</sup>, Christer Sandin<sup>1</sup>, Ewa Karchniwy<sup>12, 26</sup>, Luiz Felipe S. Rodrigues<sup>14, 27</sup>, Alexander Hubbard<sup>28</sup>, Gustavo Guerrero<sup>29</sup>, Andrew Snodin<sup>14</sup>, Illa R. Losada<sup>1</sup>, Johannes Pekkilä<sup>9</sup>, and Chengeng Qian<sup>30</sup>

<sup>1</sup> Nordita, KTH Royal Institute of Technology and Stockholm University, Sweden <sup>2</sup> Department of Astronomy, Stockholm University, Sweden <sup>3</sup> McWilliams Center for Cosmology & Department of Physics, Carnegie Mellon University, PA, USA <sup>4</sup> GLOBE Institute, University of Copenhagen, Denmark <sup>5</sup> Space Research Institute, Graz, Austria <sup>6</sup> Institute of Physics, University of Graz, Graz, Austria <sup>7</sup> Bruker, Potsdam, Germany <sup>8</sup> New Mexico State University, Department of Astronomy, Las Cruces, NM, USA <sup>9</sup> Astroinformatics, Department of Computer Science, Aalto University, Finland <sup>10</sup> Gesellschaft für wissenschaftliche Datenverarbeitung mbH Göttingen, Germany <sup>11</sup> SINTEF Energy Research, Trondheim, Norway <sup>12</sup> Norwegian University of Science and Technology, Norway <sup>13</sup> Bank of America Merrill Lynch, London, UK <sup>14</sup> School of Mathematics, Statistics and Physics, Newcastle University, UK <sup>15</sup> No current affiliation <sup>16</sup> University of Nevada, Las Vegas, USA <sup>17</sup> Niels Bohr International Academy, Denmark <sup>18</sup> CINES, Montpellier, France <sup>19</sup> School of Mathematics and Statistics, University of Glasgow, UK <sup>20</sup> Max Planck Institute for Solar System Research, Germany <sup>21</sup> Institute for Astrophysics, University of Göttingen, Germany <sup>22</sup> Indian Institute of Astrophysics, Bengaluru, India <sup>23</sup> Department of Physics & Astronomy, Bates College, ME, USA <sup>24</sup> Laboratoire d'Astrophysique, EPFL, Sauverny, Switzerland <sup>25</sup> Avignon Université, France <sup>26</sup> Institute of Thermal Technology, Silesian University of Technology, Poland <sup>27</sup> Radboud University, Netherlands <sup>28</sup> Department of Astrophysics, American Museum of Natural History, NY, USA <sup>29</sup> Physics Department, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil <sup>30</sup> State Key Laboratory of Explosion Science and Technology, Beijing Institute of Technology, China

## Summary

The Pencil Code is a highly modular physics-oriented simulation code that can be adapted to a wide range of applications. It is primarily designed to solve partial differential equations (PDEs) of compressible hydrodynamics and has lots of add-ons ranging from astrophysical magnetohydrodynamics (MHD) (A. Brandenburg & Dobler, 2010) to meteorological cloud microphysics (Li et al., 2017) and engineering applications in combustion (Babkovskia et al., 2011). Nevertheless, the framework is general and can also be applied to situations not related to hydrodynamics or even PDEs, for example when just the message passing interface or input/output strategies of the code are to be used. The code can also evolve Lagrangian (inertial and noninertial) particles, their coagulation and condensation, as well as their interaction with the fluid. A related module has also been adapted to perform ray tracing

## Meetings



# Pencil Code community

- **Annual user meetings (this year's meeting will be Oct 27-31 at CERN, next week!)**
- **If you want to contribute to the code, register at [account.pencil-code.org](https://account.pencil-code.org) and apply for write access, ideally contact one of the code administrators.**
- **Pencil Code is fully open source, so you can enjoy of all current and new developments. If you make developments, please include them in the public version so everybody else can also benefit from them!**
- **If you run into issues or want to stay updated, join the Google groups [pencil-code-discuss](https://groups.google.com/g/pencil-code-discuss) and [pencil-code-newsletter](https://groups.google.com/g/pencil-code-newsletter)**

☆ pencil-code-discuss 185 members

Oct 15 : Axel office hours — Dear all, Office hours were originally planned for this hour, <https://norlx65.nordita.org/~brandenb/>

Sep 18 : yuvraj....@gmail.com, Kishore Gopalakrishnan Adding a pencil for sore diffusion — Hi Kishore, Thanks for your help. I was able to declare a pencil. Best, Yuvraj On Thursday, September

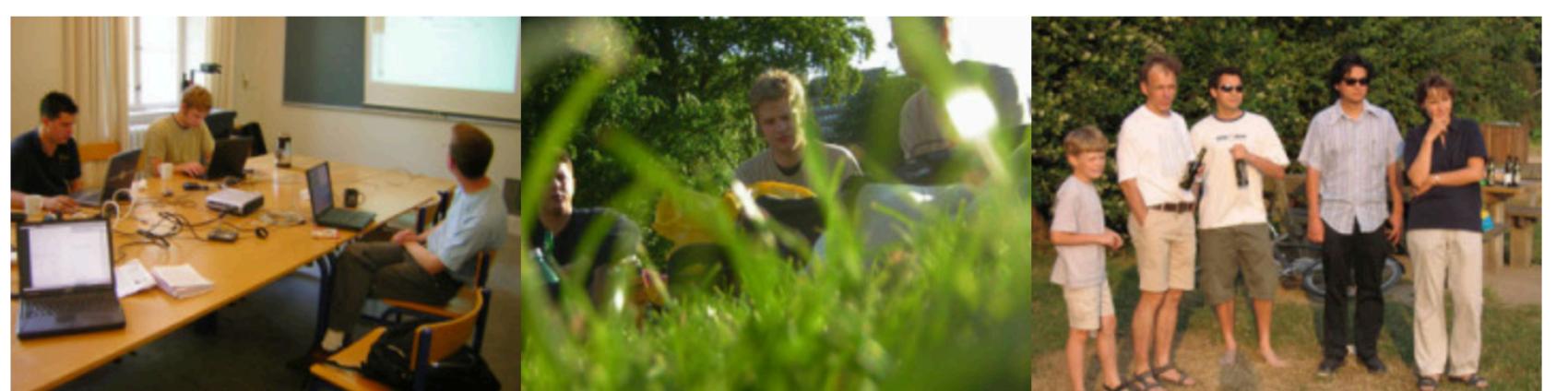
Sep 17 : Axel 4 office hours — Dear all, This is a reminder of the office hours in 30 min on <https://stockholmuni.zoom.us/j/>

Sep 8 : Alberto Roper Pencil Code school and 2025 user meeting — Dear all, This is a reminder of the 2025 Pencil Code user meeting that will take place at CERN on

Sep 5 : Axel Pencil Code Newsletter 2025/1 — Dear all, A new Pencil Code Newsletter is available on the link: <https://norlx65.nordita.org/~>

1-30 of 815 < >

- 27-31 Oct, 2025: [21th meeting](#) [agenda] in Geneva, (CERN) (Switzerland).
- 23-27 Sep, 2024: [20th meeting](#) [agenda] in Barcelona, Institute of Space Sciences (ICE-CSIC / IEEC) (Spain).
- 4-8 Sep, 2023: [19th meeting](#) [agenda] in Graz, Institute of Physics, University of Graz (Austria).
- 4-10 May, 2022: [18th meeting](#) [agenda] in Bangalore, IIA (India).
- 17-21 May, 2021: [17th meeting](#) [agenda] in Lausanne, EPFL (Switzerland).
- 27-31 Jul, 2020: [16th meeting](#) [agenda] in Glasgow, Glasgow University (UK).
- 12-16 Aug, 2019: [15th meeting](#) [agenda] in Espoo, Aalto University (Finland).
- 11-15 Jun, 2018: [14th meeting](#) [agenda] in Boulder, University of Colorado (USA).
- 10-14 Jul, 2017: [13th meeting](#) [agenda] in Newcastle, Newcastle University (UK).
- 08-12 Aug, 2016: [12th meeting](#) [agenda] in Graz, Space Research Institute, Academy of Sciences (Austria).
- 11-15 May, 2015: [11th meeting](#) [agenda] in Trondheim, Norwegian University of Science and Technology (Norway).
- 07-11 Jul, 2014: [10th meeting](#) [agenda] in Göttingen, Max Planck Institute for Solar System Research (Germany).
- 17-20 Jun, 2013: [9th meeting](#) [agenda] in Lund, Lund Observatory (Sweden).
- 18-21 Jun, 2012: [8th meeting](#) [agenda] in Helsinki, Physics Department (Finland).
- 24-28 Oct, 2011: [7th meeting](#) [agenda] in Toulouse, Observatoire Midi-Pyrénées (France).
- 26-30 Jul, 2010: [6th meeting](#) [notes] in New York, American Museum of National History (USA).
- 24-28 Aug, 2009: [5th meeting](#) [agenda] in Heidelberg, Max Planck Institute for Astronomy (Germany).
- 19-22 Aug, 2008: [4th meeting](#) [agenda] in Leiden, Leiden Observatory (Netherlands).
- 14-17 Aug, 2007: [3rd meeting](#) [notes] in Stockholm, Nordita (Sweden).
- 13-15 Jul, 2006: [2nd meeting](#) [videos] in Copenhagen, Nordita (Denmark).
- 26-28 Jun, 2005: [1st meeting](#) [agenda] in Copenhagen, Nordita (Denmark).

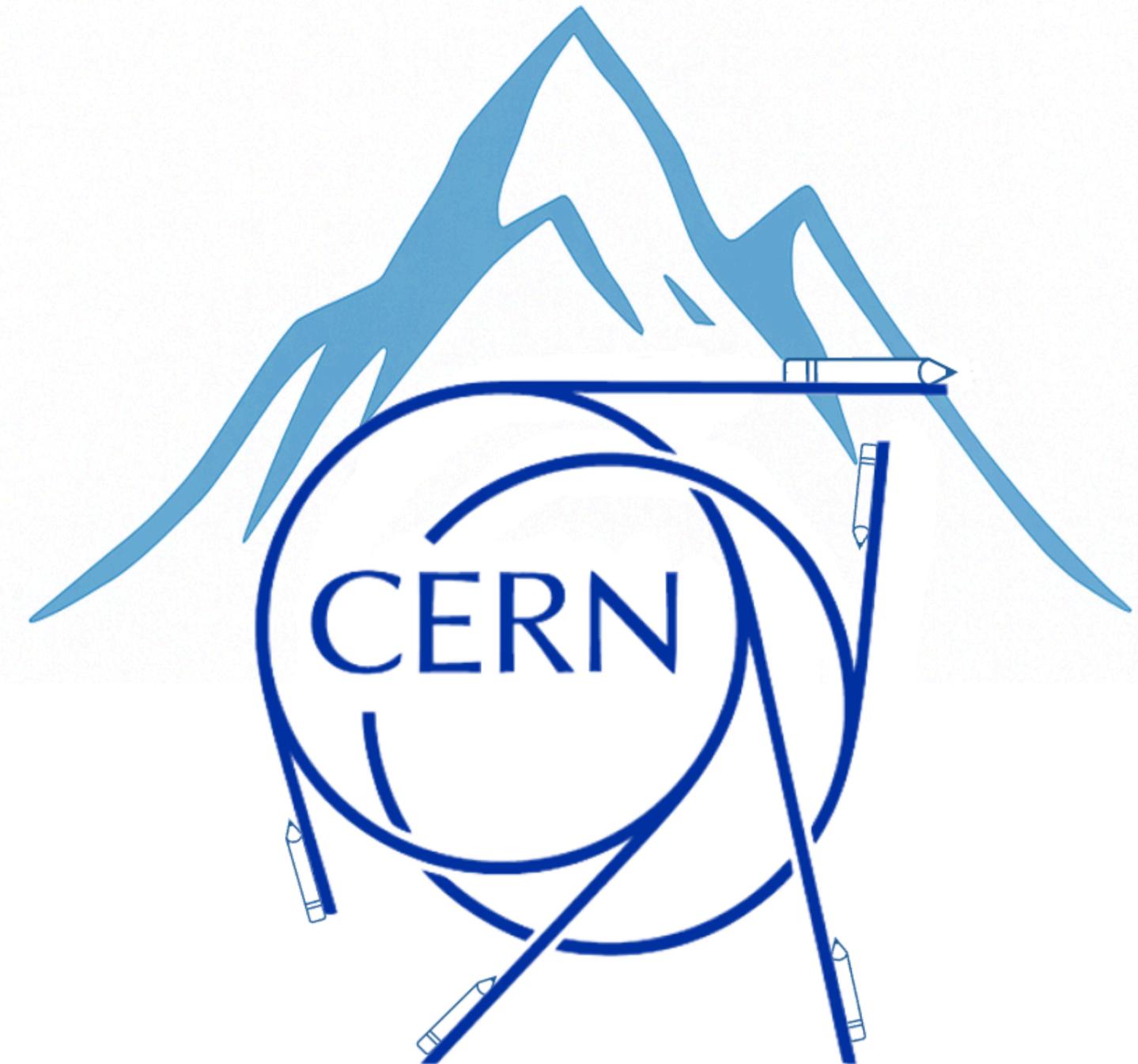


# *Welcome to the 1st Pencil Code school on early Universe physics and gravitational waves!*

**Objective of the school: learn  
the basics of the code and  
the tools for you to keep  
working with it in the future!**

**For more, user meeting on  
Oct 27-31**

**Accelerating the  
Pencil Code**



**Pencil Code User Meeting**  
October 2025 - CERN (Switzerland)