Università di Torino

Participation to the

Astrophysics & Cosmos Observations (Spoke 3)

[National Centre for HPC, Big Data and Quantum Computing]

A. Mignone (PO),

F. Massaro (PA), D. Gandolfi (PA), F. Pace (PO),

G. Boffetta (PO), F. De Lillo (PA), Susanna Terracini (PO),

V. Barutello (PA), A. Boscaggin (PA)

Università di Torino (UniTo)

- UniTo is divided into 55 departments located in 13 faculties. Its academic structure involves also several schools, research centers and other facilities distributed over the whole city and neighbourhood.

- Ranked among the first 300 University worldwide and 5th in Italy (ARWU Shanghai);
- **UniTo** is ranked 3rd for research activities according to ANVUR.

- **Academic staff**: 527 PO, 975 PA, 650 Researchers (43 % women), Administrative staff: 1738 (tenure tracks);
- **Students** (2021/22): ~ 81.200 (enrolled - 1,100 PhD);
- **Graduates** (2021): ~ 15,000 (~ 10.100 Bachelor, > 4,800 Master);

- **Employment rate** (within 1 year from degree): 54.8%
- **International Networks** (2021/22): 30 international double degree programs, over 430 academic cooperation agreement with universities and research institution from 79 countries;

UNIVERSITÀ DEGLI STUDI DI TORINO

Dipartiments Involved

Physics Department

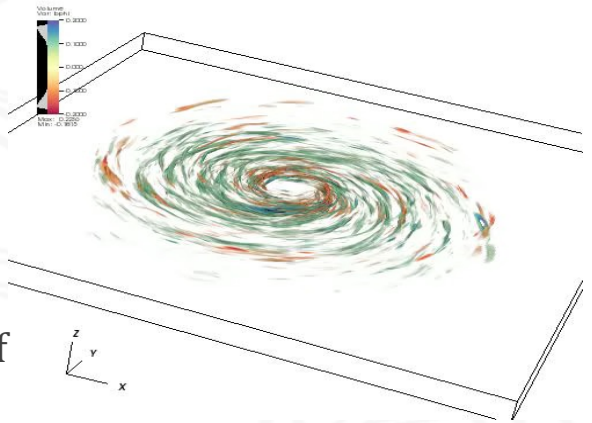
- **Andrea Mignone** (PO) - Head: *High-energy Astrophysics, plasma physics, numerical methods in magnetized fluids. Main developer of the PLUTO code for HPC of plasma dynamics.*
- **G. Boffetta** (PO) – *Turbulent convection & geophysical flows, numerical computations of incompressible fluid dynamics.*
- **F. De Lillo** (PA) – *Nonlinear waves & Turbulence, direct numerical simulations motility in fluid environments, mainly swimming of micro-organisms in chaotic and turbulent flows.*
- **F. Massaro** (PA) - *Observational high-energy astrophysics, Radiative Process, multi-frequency data reduction, statistical method & machine learning.*
- **D. Gandolfi** (PA) – *Exoplanet detection, space missions (CoRoT, Kepler, K2, CHEOPS, TESS), High-precision radial velocity follow-up of transiting planets;*
- **F. Pace** (RTD) – *Linear and nonlinear evolution of cosmological models beyond LambdaCDM, N-body and ray-tracing simulations. Main developer of the modified Einstein-Boltzmann codes eos_class and qsa_class.*

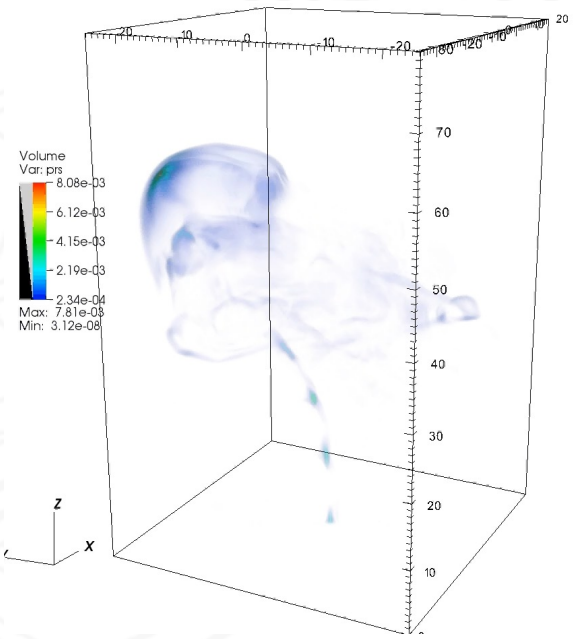
Math Department

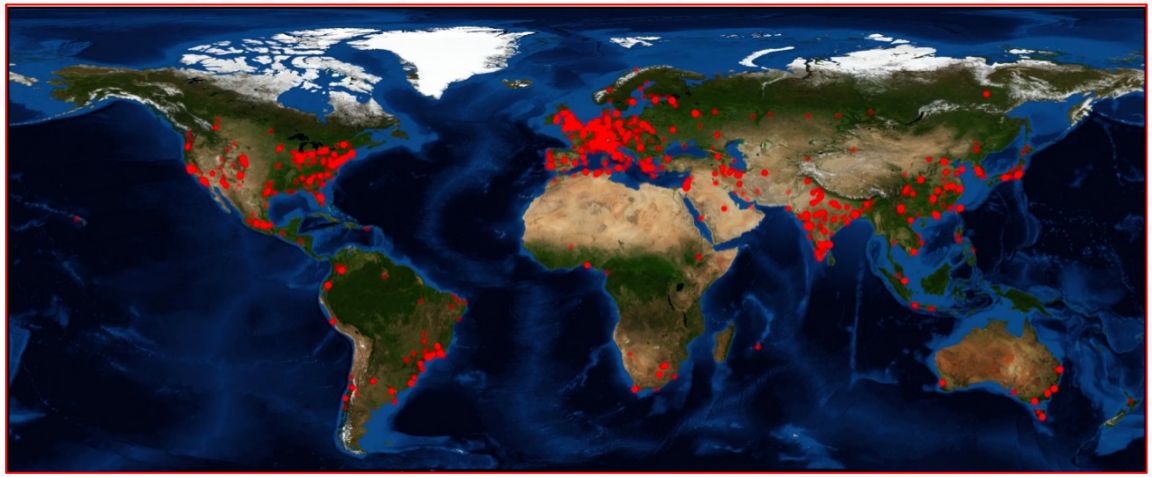
- **Susanna Terracini** (PO) – Head: *Mathematical Analysis, Dynamical System theory, Celestial Mechanics, N-body problem, Reaction-Diffusion models, Calculus of Variations, Pattern Formation*. ERC laureate 2013 (COMPACT advanced grant). Recipient of the 2020 Julusz Schauder medal for outstanding contributions in Nonlinear Analysis.
- **Vivina Barutello** (PA) - *Mathematical Analysis, Variational and Topological methods applied to problems of Celestial Mechanics and N-body problem, stability of trajectories.*
- **Alberto Boscaggin** (PA) - *Mathematical Analysis, Hamiltonian systems, N-body systems, regularization of collisions, oscillatory solutions*.
- **Lorenzo Fatibene** (PO) - *Mathematical Physics with skills in relativity theory cosmology, mathematical models in astrophysics, differential geometry.*
- **Mattia Bergomi** - PhD in Computer Sciences with skills in innovative Machine Learning techniques, Algebraic Topology, Cognitive Sciences

Computational Plasma Astrophysics (→ A. Mignone)

- Computational modelling of astrophysical plasma or fluids using classical and relativistic numerical simulations.
- Development, maintenance and distribution of the PLUTO code for astrophysical plasma dynamics (http://plutocode.ph.unito.it);
- The PLUTO code ranks world-leading HPC excellence in a variety of astrophysical research fields and institutions around the world.
- The latest releases of the code (Dec 2018 and Nov 2020) have received ~ 1600 and ~ 1000 downloads, respectively.
- → Active contribution to WP1 & WP2







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Mathematics Dept (→ Susanna Terracini)

A Mathematical Urban Plan for the Space

- Goal: understand global dynamics, (the set of all possible trajectories), their behaviour and their classification according to different applications to space sciences.
- Method: a new theoretical and computational mathematical framework enabling a global understanding of the evolution of high-dimensional complex dynamical systems in Celestial Mechanics and Astrodynamics.
- By a transformative combination of computational intelligence and advanced mathematics, we will perform a systematic reasoned search for the dynamical structures and their connections.
- → Interdisciplinary approach by importing and transforming computer-assisted methods and computational intelligence techniques.
- → Active contribution to WP2 & WP3.

The End

Foreseen Activites within the Spoke

- Development of new generation of **computational algorithms** and **plasma codes**, targeting **exa-scale** architecture and astrophysical and laboratory plasma [WP1 / WP2];

- Development of new class of **visualization** and data analysis **tools** with the ability to easily browse through complex 3D data sets [WP1];

- Big Data: Expand current capabilities of the OCCAM-C3S computing facility at UniTo to improve i) data reduction / algorithms of **massive observational data** (e.g. LOFAR observations and - upcoming – SKA) (ii) **data analysis** of observations carried out with new optical instruments as MUSE and ERIS mounted at the Very Large Telescope; [WP3]

- Machine Learning & AI techniques;