Federico Fraternale

federico.fraternale@uah.edu

EDUCATION

Politecnico di Torino, Torino, Italy

- Ph.D. in Aerospace Engineering *Cum Laude* — Jan 2014 – Oct 2017
  Dissertation: *"Internal waves in fluid flows. Possible coexistence with turbulence"*.
  Supervisor: Prof. Daniela Tordella (PoliTo, DISAT).
  Focus: hydrodynamic stability, propagation of waves and wave packets in shear flows; vorticity and stability thresholds; solar wind turbulence, spectral data analysis of incomplete time series from the *Voyager* mission.
- M.S. in Aerospace Engineering (Aero-gas Dynamics) — Oct 2010 – Mar 2013
  Grade: 110 / 110 *Cum Laude*
  Thesis: *"Frequency transient of three-dimensional perturbations in shear flows, similarity properties and wave packets linear formation"*, supervisor: Prof. D. Tordella (PoliTo, DISAT); Co-supervisor: Prof. G. Staffilani (MIT, Math.).
- B.S. in Aerospace Engineering — Sep 2007 – Oct 2010
  Grade: 110 / 110 *Cum Laude*
  Thesis: *"Development of a CFD model for an electro-hydraulic servo-valve"*, Supervisor: Prof. P. Maggiore (PoliTo, DIMEAS)

Massachusetts Institute of Technology (Math. Dept.), Cambridge (MA), USA

- Visiting Student, Advisor Prof. G. Staffilani — Nov 2012 – Mar 2013
  Focus: M. S. Thesis. Solutions of the Orr-Sommerfeld/Squire initial value problem for traveling waves in shear flows.
  Funding: Final Project award fellowship (Erasmus+ Programme).

ACADEMIC POSITIONS

The University of Alabama in Huntsville (CSPAR), Huntsville (AL), USA

- Research Scientist I — Nov 2019 – present
  Project: *Turbulence as Indicator of Physical Processes at the Heliospheric Interface*, NASA H-GI Program, grant 80NSSC19K0260.
  Advisor and PI: Prof. N. V. Pogorelov.

Politecnico di Torino (DISAT), Torino, Italy

- Postdoctoral researcher — Jan 2018 – Jan 2020
  Program: *Internal waves, local fluctuations and turbulence in fluids* (FOIFLUT, 37/17/F/AR-B).
  Advisor: Prof. D. Tordella (DISAT)
- Reaserch fellow — Mar 2017 – Sep 2017
  Program: *Microphysics of warm clouds, turbulence and atmospheric waves*, Project: COMPLETE (Marie Curie ITN-ETN Network), Coordinator: Prof. D. Tordella.

MIT - Kavli Institute for Astrophysics and Space Research, Cambridge (MA), USA

- Visiting reasercher — Feb 2015 – Mar 2015
  Project: MITOR - *Laboratory simulation of planet-solar wind and interstellar medium/heliosphere interactions* (2012-2015),.
  visor Dr. J. D. Richardson

TEACHING/ MENTORING

Politecnico di Torino, Torino, Italy — Jan 2014 – Nov 2019

- Lectures and labs focused on hydrodynamic stability theory and turbulence, numerical simulations of waves and turbulent flows (course manager: Prof. D. Tordella)
  "Turbulent flows" (M. S. in Aerospace Engineering)
  "Fluid Dynamics" (M. S. in Mathematical Engineering)
  "Hydrodynamics Stability" (Doctoral course)
  Lab: Kelvin–Helmholts instability experiment, see http://www.disat.polito.it/it/il_dipartimento/strutture_interne/laboratori_interni/laboratorio_didattico_instabilita_nei_fluidi
- Mentoring experience of four M. S. students and four B. S. students

PUBLICATIONS

PHD DISSERTATION

Federico Fraternale, "Internal waves in fluid flows. Possible coexistence with turbulence". DOI: 10.6092/polito/porto/2687873

JOURNAL PAPERS

- F. Fraternale, N. V. Pogorelov, and L. F. Burlaga. "Signatures of Intermittency and Fine-scale Turbulence in the Very Local Interstellar Medium" *Astrophys. J. Letters*, in press.
- F. Fraternale, N. V. Pogorelov, J. D. Richardson, and D. Tordella. "The structure of magnetic turbulence in the heliosheath region observed by *Voyager 2* at 106 AU" *J. Phys. Conf. Series* 1225, 012006 (2019). DOI: 10.1088/1742-6596/1225/1/012006.
- F. Fraternale, N. V. Pogorelov, J. D. Richardson, and D. Tordella. "Magnetic turbulence spectra and intermittency in the heliosheath and in the local interstellar medium" *Astrophys. J.* 872:40 (2019). DOI: 10.3847/1538-4357/aafd30.

- L. Sorriso-Valvo, G. De Vita, F. Fraternale, et al. "Sign singularity of the local energy transfer in space plasma turbulence" *Frontiers in Physics* 7:108 (2019). DOI: 10.3389/fphy.2019.00108.
- F. Fraternale, G. Nastro, D. Tordella. "Wave focusing and related multiple dispersion transitions in plane Poiseuille flows", 2019, under review.
- L. Sorriso-Valvo et al. "Turbulence-driven ion beams in the magnetospheric Kelvin-Helmholtz instability" *Phys. Rev. Lett.* 122:035102 (2019). DOI: 10.1103/PhysRevLett.122.035102.
- F. Fraternale, L. Domenicale, G. Staffilani, and D. Tordella. "Internal waves in sheared flows: Lower bound of the vorticity growth and propagation discontinuities in the parameter space" *Phys. Rev. E* 97: 063102 (2018). DOI:10.1103/PhysRevE.97.063102.
- F. De Santi, F. Fraternale, and D. Tordella. "Dispersive-to-nondispersive transition and phase-velocity transient for linear waves in plane wake and channel flows" In: *Phys. Rev. E* 93:3 (2016). DOI: 10.1103/PhysRevE.93.033116. Press releases: *Waves in fluids: Governing mechanisms revealed (AlphaGalileo, PhysOrg)*; *Onde nei fluidi: svelati i meccanismi che le regolano (GravitàZero*, *MeteoWeb)*.
- F. Fraternale, L. Gallana, M. Iovieno, M. Opher, J. D. Richardson, and D. Tordella. "Turbulence in the solar wind: spectra from Voyager 2 data at 5 AU" In: Phys. Scripta (Invited Comment) 91:2 (2016), pp. 394–401. DOI: 10.1088/0031-8949/91/2/023011.
- L. Gallana, F. Fraternale, M. Iovieno, S. M. Fosson, E. Magli, M. Opher, J. D. Richardson, and D. Tordella. "Voyager 2 solar plasma and magnetic field spectral analysis for intermediate data sparsity" In: J. Geophys. Res.: Space Physics 121.5 (2016), pp. 3905–3919. DOI: 10.1002/ 2015JA021830.
- M. Iovieno, L. Gallana, Fraternale F. J. D. Richardson, M. Opher, and D. Tordella. "Cross and magnetic helicity in the outer heliosphere from Voyager 2 observations" In: Eur. J. Mech. B/Fluids 55.2 (2016), pp. 394–401. DOI: 10.1016/j.euromechflu.2015.08.009.
- L. Pace, M. Ferro, F. Fraternale, M. Dalla Vedova, A. Caimano, and P. Maggiore, "Comparative analysis of a hydraulic servo-valve" In: Int. J. Fluid Power 14 (2013), pp. 53–62.

INTERNATIONAL CONFERENCES (LAST 10)

- F. Fraternale, N. Pogorelov, T. K. Kim, "Waves and Turbulence in the Local Interstellar Medium", 19th AIAC, Santa Fe, NM, USA, 9–13 March 2020.
- F. Fraternale, N. Pogorelov, J. D. Richardson, D. Tordella, "Observed scaling of turbulence in the inner and outer heliosheath", Workshop - Universality: Turbulence Across Vast Scales, Flatiron Inst. New York City, NY, USA, 2–6 December 2020.
- F. Fraternale, N. Pogorelov, J. D. Richardson, D. Tordella, "Turbulent Cross-scale Evolution of Intermittency and Magnetic Energy Flux: Voyager Observations in the Inner Heliosheath and Local Interstellar medium", AGU Fall Meeting 2019, San Francisco, USA, 9-14 December 2019.
- F. Fraternale, N. Pogorelov, J. D. Richardson, D. Tordella, "Observed scaling of turbulence in the inner and outer heliosheath", Workshop *Universality: turbulence across vast scales*, Flatiron Inst. , New York City, USA, 2-6 December 2019.
- F. Fraternale, N. Pogorelov, J. D. Richardson, D. Tordella, "Magnetic turbulence anisotropy and cascade rates in the heliosheath and local interstellar medium as seen by the Voyagers", ETC17 - 17th European Turbulence Conference, Torino, Italy, September 3-6, 2019.
- G. Nastro, F. Fraternale, D. Tordella, "Wave focusing and related multiple dispersion transitions of perturbation waves in the plane Poiseuille flow", ETC17 - 17th European Turbulence Conference, Torino, Italy, September 3-6, 2019.
- N. V. Pogorelov, F. Fraternale, M. Gedalin, J. Heerikhuisen, T. K. Kim, V. Roytershteyn, M. Zhang, "Turbulence and instabilities at the heliospheric interface", Minisymposium at ETC17 - 17th European Turbulence Conference, Torino, Italy, September 3-6, 2019.
- L. Sorriso-Valvo, O. Pezzi, F. Catapano, F. Valentini, S. Perri, D. Perrone, F. Fraternale, "Turbulence-driven ion beams in space plasmas", VLASOVIA 2019 - 6$_{th}$ International Workshop on the Theory and Applications of the Vlasov Equation, Strasbourg, France, July 22-25, 2019.
- F. Fraternale, N. Pogorelov, J. D. Richardson, D. Tordella, "Intermittency and cascade rate of turbulent magnetic energy in the inner heliosheath and local interstellar medium from in-situ Voyager 1 and 2 measurements between 100 AU and 140 AU", ASTRONUM 2019 - 14th Int. Conf. on Numerical Modelling of Space Plasma Flows, Paris, France, July 1-5, 2019.
- L. Sorriso-Valvo et al., "Turbulence-Driven Ion Beams in the Magnetospheric Kelvin-Helmholtz Instability", EGU General Assembly 2019, Vienna, Austria, April 7-12, 2019.

RESEARCH My current research project is focused on turbulence and dissipation processes in the outer heliosphere and in very local interstellar medium, through analysis of *Voyager* data sets and theoretical/numerical modeling.

Fields of expertise: solar wind and magnetohydrodynamic turbulence. •Turbulence and wave dynamics in fluids, including: hydrodynamic stability theory of shear flows, wave propagation and wave dispersion, transition to turbulence, atmospheric cloud turbulence and droplet dynamics, shear-less mixing. •Data analysis of sparse data sets (missing data recovery, spectral and multi-scale statistical analysis). •Mathematical modeling, partial differential equations and population balance equations. •Numerical methods and optimization procedures; •Direct numerical simulations of turbulence.

1 July 2020,

Federico Fraternale