PERSONAL INFORMATION

GALTIER Sébastien
24 February 1971, French
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• CURRENT POSITION

2018 – Now	**Full Professor** of Exceptional Class (National promotion) at Université Paris-Saclay

• PREVIOUS POSITIONS

2014 – 2018	Professor (1st class – National promotion) Laboratoire de Physique des Plasmas, Université Paris-Sud
2012 – 2014	Professor (2nd class) Institut d'Astrophysique Spatiale, Université Paris-Sud
2001 – 2012	Assistant Professor Institut d'Astrophysique Spatiale, Université Paris-Sud
1999 – 2000	Research Assistant (European contract; coordinator: P. Tabeling, ENS Paris) Mathematics Institute, University of Warwick, UK

• FELLOWSHIPS AND AWARDS

2024	**Grand Prix Cécile DeWitt-Morette** from the French Academy of Sciences (International prize; École de Physique des Houches / Fondation CFM)
2023 – 2026	**Simons Collaboration grant** in Mathematics & Physical Sciences
2018 – 2023	**Senior** fellow of Institut Universitaire de France
2008 – 2013	**Junior** fellow of Institut Universitaire de France

• EDUCATION

2003	Habilitation à Diriger des Recherches (HDR), Université Paris-Sud
1995 – 1998	**PhD Thesis** '*Turbulence and intermittency in magnetohydrodynamics*' (Summa cum laude); Dir. Annick Pouquet ; Observatoire de la Côte d'Azur, Nice, France
1994 – 1995	Military Service with alpine troops
1993 – 1994	Master in Astrophysics & Magistère Physique École Normale Supérieure & Université Grenoble

• TEACHING ACTIVITIES

2001 – Now	I teach 192h/year (Lectures and Tutorials; in French and English) MHD (Master 2), plasma physics (Master 1), and mathematics (Licence 3)
1999 – 2000	Research Assistant – Numerical methods (in English) – University of Warwick, UK
1996 – 1998	PhD student – Experimental physics – University of Nice, France
1995 – 1997	PhD student – Physics – Higher School Preparatory Classes, Nice, France

• ORGANISATION OF (RECENT) SCIENTIFIC MEETINGS

Sept. 2024	Workshop on '*Wave Turbulence*' in École des Houches, France, 60 participants
Dec. 2018	International conference at École polytechnique, France, 85 participants
July 2016	International summer school (2 weeks) in Cargèse, France, 57 participants
Jan. 2014	National workshop in solar and plasma physics, Sète, France, 130 participants

• SUPERVISION OF PHD STUDENTS AND POSTDOCTORAL FELLOWS

PhD students:

- Eric Buchlin (2001-12/2004, ENS) on "Heating of the solar corona and turbulence". Supervising at 30%. Currently CNRS position at IAS-Orsay.
- Barbara Bigot (2005-04/2008, EDOM) on "Waves and turbulence in anisotropic MHD". Supervising at 100%. Currently in industry.
- Romain Meyrand (2009-03/2013, EDOM) on "Turbulence at high frequencies in the solar wind". Supervising at 100%. Currently: researcher at University of Otago, New-Zealand.
- Supratik Banerjee (2011-2014, X) on "Compressible turbulence in space and astrophysical plasmas". Supervising at 100%. Currently: Assistant Professor in Kanpur (India).
- Mélissa Menu (2016-12/2019, Labex) on "Magnetic field generated by dynamo effect in astrophysical objects under rotation". Supervising at 50%. Currently: permanent position at CEA-DAM in France.
- Renaud Ferrand (2018-10/2021, X) on "Multiscale compressible turbulence in astrophysical plasmas". Supervising at 50%. Currently: permanent position at CEA-DAM in France.
- Vincent David (2020-09/23, EDOM) on "Multiscale solar wind turbulence". Supervising at 70%. Currently: postdoc position at University of New Hampshire.
- Pauline Simon (2020-09/23, DIM-ACAV) on "Compressible turbulence in the solar wind". Supervising at 30%. Currently: postdoc position at Queen Mary University of London.
- Benoit Gay (10/2022-, ENS) on "Gravitational wave turbulence". Supervising at 100%.

Postdoctoral fellows:

- S. Parenti (2004-2006, ERC). Supervising at 30%. Currently position at IAS-Orsay
- A. Canou (2012-2013, CNES). Supervising at 30%. Engineer at Ecole Polytechnique
- K. Kiyani (2015-2016, ANR). Supervising at 30%. Position in industry in UK
- N. Andrés (2016-2018, X). Supervising at 50%. CNR position in Buenos Aires
- B. James (2024-2026, Simons). Supervising at 100%

• (SOME) INSTITUTIONAL RESPONSIBILITIES

2023 – Now	**Director of the Master** (second year) in '*Plasma Physics and Fusion*' (Université Paris-Saclay, Institut Polytechnique de Paris, Sorbonne-Université)
2015 – 2023	Member of the steering committee of the Master 2 '*Plasma Physics and Fusion*'
2011 – 2015	**Director of the Master** 2 in '*Plasma Physics*', Université Paris-Sud
2020 – Now	Member of the council of a doctoral school, Université Paris-Saclay. This council selects graduate students for a PhD thesis
2009 – 2014	**President of a national program** (involving ~200 researchers) on space and solar plasmas (PNST/INSU/CNRS). Member of the PNST council in 2006-2009.
2008 – 2011	Elected member of the national council of universities (CNU), France
2010 – 2014	Member of the "*Sun-Heliosphere-Magnetosphere*" group at CNES (Assessment committee on space research at the French space agency)
2011 – 2014	Member of the scientific council on the solar telescope THEMIS

• REVIEWING ACTIVITIES

2001 – Now	Referee of more than 150 papers for more than 20 different international journals
2001 – Now	Member of 7 HDR (Habilitation) committees
2001 – Now	Member of 31 PhD thesis committees

• RESEARCH TOPICS

My research focuses on turbulence in astrophysics and cosmology. I use both high-level mathematical tools and massive numerical simulations to study the properties of turbulence and discover new fundamental laws. The fields of application are varied: solar wind plasma, supersonic interstellar medium, solar coronal heating and primordial gravitational waves. Magnetohydrodynamics (MHD) and general relativity are the main equations used to study these issues.

• PUBLICATIONS AND COMMUNICATIONS

Author ORCID: https://orcid.org/0000-0001-8685-9497

- **105** refereed articles (**2.9** authors/article ; **46** as 1st author; **34** as 2nd author)
- **11** Physical Review Letters (including one as *Editors' Suggestion*)

- **65 invited** international conferences
- **33** other international conferences
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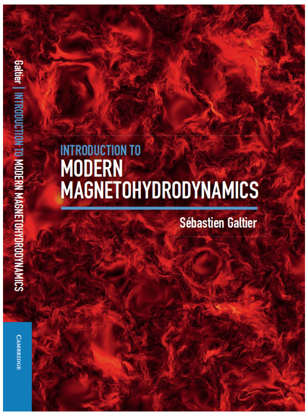
- **33 invited** national conferences
- **9** other national conferences

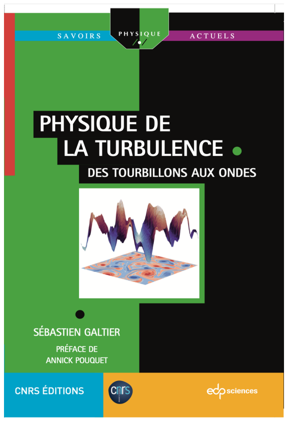
- **7 invited** seminar abroad
- **35 invited** seminar in France

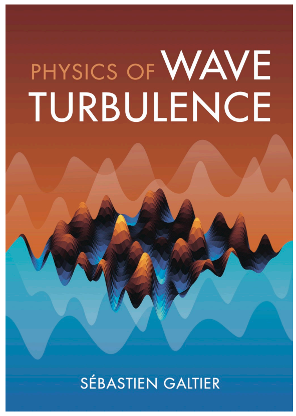
- Citations ~ **5000 ;** h index = **38** (google scholar) https://scholar.google.fr/citations?user=JeDgazYAAAAJ&hl=fr

- **4** books (2 in English & 2 in French) + participation to **1** book

2013 **2016** **2021** **2023**







• OTHER QUALIFICATIONS

1997: Qualification for the French National Championship of marathon (2h38')
1997: Qualification for the French National Championship of half-marathon (1h14')

- **IMPORTANT PUBLICATIONS (see list below)**

Nature of Alfvén wave turbulence

Magnetohydrodynamics (MHD) is the basic model to describe the large-scale dynamics of the visible matter in the universe, which is essentially in the form of plasma (Galtier, 2016 [A71]). As shown by the observations of the close (heliosphere) and farther (interstellar medium) environments, space and astrophysical plasmas are generally turbulent. Since the seminal papers by Iroshnikov (1964) and Kraichnan (1965), MHD turbulence is thought to have its origin in the stochastic collisions of counter propagating Alfvén (incompressible MHD) waves. The phenomenological model based on this idea predicts an isotropic energy spectrum different from that of hydrodynamics based on the interaction of vortices. However, in the 1980s it was realized that in the presence of a large-scale magnetic field $\mathbf{B_0}$ – a necessary condition for the generation of Alfvén waves – the energy redistribution mechanism is non-isotropic with a weakening of the turbulent cascade along the $\mathbf{B_0}$ direction (Montgomery & Turner, 1981; Shebalin et al., 1983). A first unsuccessful attempt to develop a theory for Alfvén wave turbulence (Sridhar & Goldreich, 1994) led to some confusion about the elementary bricks of MHD turbulence (Ng & Bhattacharjee, 1996).

We published (Galtier et al., 2000 [A8]) a rigorous theory called *Wave Turbulence (see eg.* Nazarenko, 2011) which is based on an asymptotic (and uniform) development of statistical quantities (two-point correlations) in Fourier space. We explained why three-wave resonant interactions are dominant at main order in the nonlinear transfer of energy from large to small scales, and how these transfers become non-isotropic with a cascade frozen along $\mathbf{B_0}$. The subtle point is that three-wave interactions always involve the slow mode ($k_{//}=0$, $k_{//}$ being the component of $\mathbf{k}$ along the $\mathbf{B_0}$ direction). We found the exact stationary solution (called Kolmogorov-Zakharov spectrum) which scales in the simplest case as $k_\perp^{-2}$. We showed that Alfvén wave turbulence becomes strong at small scales. The numerical simulation of the wave turbulence equations (called kinetic equations) revealed the existence during the non-stationary phase of an energy spectrum not compatible with the stationary solution. This is the first time that this spectral anomalous was detected in turbulence. It is now widely found in weak and strong turbulence and is understood as a self-similar solution of the second kind (Thalabard et al., 2015 [A66]). By solving this major problem of plasma physics, the Alfvén wave turbulence theory has become a reference (third most cited paper of J. Plasma Physics created in 1968) as it clarifies the foundation of MHD turbulence. Since then, Alfvén wave turbulence has been mentioned to explain measurements in the Jovian magnetosphere (Saur et al., 2002) and to describe the solar coronal loops (Rappazzo et al., 2007). Over the last ten years, I have returned to this fundamental problem to demonstrate the feasibility of such a regime using 3D direct numerical simulations. This is a non-trivial task as it requires the use of massive numerical resources and the development of specific tools dedicated to wave turbulence. With young researchers, we have succeeded in reproducing this regime. The very detailed study also allowed us to reveal new properties, including the transition from weak to strong wave turbulence described by the critical balance phenomenology (Meyrand, Kiyani & Galtier, 2015 [A65]; Meyrand, Galtier & Kyiani, 2016 [A67]).

Rotating hydrodynamic turbulence

The Navier-Stokes equations are generally considered the archetypal model for studying turbulence. This is so commonly accepted that the word 'turbulence' is often used as a synonym for 'incompressible hydrodynamic (vortex) turbulence'. It is true that the first experiments, concepts and results emerged from the study of water (Galtier, 2023 [A102]), however Navier-Stokes equations are somewhat singular since waves are not present while they are found in almost all physical systems. Among the limited results of vortex turbulence, the exact law of Kolmogorov (1941) is certainly the best known. However, such a law gives only a superficial description of turbulence because it does not inform us about the nature of nonlinear interactions, the degree of isotropy, or whether the cascade is direct or inverse.

A much deeper understanding of turbulence can be obtained by considering the presence of waves. The first theoretical breakthrough was made with the study of capillary wave turbulence (Zakharov & Filonenko, 1967). Although the system studied is based on Navier-Stokes, some manipulations have to be performed to obtain a system that describes surface waves, so it is a bit far from the original archetypal model. The very first example where wave turbulence was applied directly to Navier-Stokes (with only a mild modification) is rotating turbulence where the Coriolis force is added to the equations (stratified turbulence is another example but there is no local solution). Interestingly, it is the addition of complexity that allows us to reach a deep understanding of turbulence. I have developed such a theory for inertial wave turbulence with uniform rotation (Galtier, 2003 [A19]). Based on the resonance condition, I was able to show that this turbulence is anisotropic with an energy cascade mainly transverse to the rotation axis, however contrary to MHD, a weak cascade along the parallel direction is still possible. I derived the wave turbulence equations for energy and helicity that describe the three-wave interactions between inertial waves. The exact solution corresponds to an energy spectrum in $k_\perp^{-5/2} k_{//}^{-1/2}$ with a positive energy flux, which means that the cascade is direct. We can also show that the solution is local and find the Kolmogorov constant (David & Galtier, 2023 [A103]). Interestingly, in the limit of super-local interactions, the wave turbulence equation reduces to a simple nonlinear diffusion equation that is easy to simulate numerically. It reveals an anomalous scaling during the non-stationary phase with a steep energy spectrum in $k_\perp^{-8/3}$. This solution is understood as a self-similar solution of the second kind. Later, we discovered that the same diffusion equation is also present in a plasma physics model that describes solar wind turbulence at sub-MHD scales (Galtier & David, 2020 [A87]). This finding offers the opportunity to learn more about space plasmas through laboratory experiments. Today, several experiments have been developed to produce inertial wave turbulence and the main properties found analytically have been measured (Yarom & Sharon, 2014; Monsalves et al., 2020).

Multi-scale solar wind turbulence

The solar wind is a turbulent plasma with magnetic field fluctuations that extend, in the frequency domain, over more than 8 decades. At 1 astronomical unit, for frequencies $f \in [10^{-4}, 10^{-1}]$Hz the spectrum in $f^{-5/3}$ is generally attributed to MHD turbulence (with Taylor's hypothesis f is a proxy of the wavenumber k). Another power law close to $f^{-8/3}$ is found for $f \in [1,100]$ Hz. This corresponds to sub-MHD scales where the decoupling between ions and electrons is felt and thus where MHD is no longer valid. Dispersive waves (kinetic Alfvén and whistler waves) are also detected. The possibility of interpreting this second frequency interval as a new turbulence regime was rarely mentioned before 2000 because space probes were not precise enough to make a clear distinction between an exponential law and a power law, the former being interpreted as the manifestation of dissipation. It is mainly thanks to the Cluster/ESA mission that the presence of a second power law was firmly established (Bale et al., 2005), allowing to seriously consider a theory of turbulence at sub-MHD scales.

In Galtier (2006; [A27]), I proposed a wave turbulence theory based on Hall MHD in order to include in a simple way (fluid model) the decoupling mentioned above. It is a theory of multi-wave and multi-scale turbulence covering the MHD and Hall-MHD scales, and where Alfvén, whistler and ion-cyclotron waves are present. I found the exact solutions to the problem (anisotropic spectra) and recovered the known results in the large scale limit (Alfvén wave turbulence). The analytical study revealed a modulated spectral anisotropy at all scales, and the spectral solutions showed a transition – as in the solar wind – at the scale where the dynamics of ions and electrons begins to decouple with an energy spectrum that stiffens at sub-MHD scales. Today, it is widely recognized that turbulence can explain the fluctuations at sub-MHD scales and that Hall MHD is a relevant first (fluid) model to understand solar wind turbulence. To completement this theory, I derived an exact relation *à la Kolmogorov* to express the two-point fluctuations (increment) in terms of the magnetic fluctuations (Galtier, 2008 [A37]). This exact law reveals also a change of scaling at the ion inertial length where ions and electrons begin to decouple. Over the last ten years, with young researchers, we have studied this multiscale and multi-wave problem using 3D direct numerical simulations (Meyrand & Galtier, 2013 [A60]; Meyrand, Kiyani, Gurcan & Galtier, 2018 [A79]). The nonlinear interaction between different types of waves was identified, as well as the coexistence of weak and strong wave turbulence on the same scale.

Foundation of compressible sub/super-sonic turbulence

A fundamental understanding of compressible turbulence requires going back to the basic concepts and researching the universal laws governing the dynamics. The importance of compressible effects is widely recognized in astrophysics. For example, interstellar turbulence is supersonic with turbulent Mach numbers well above 10 (Hennebelle et al., 2012). This turbulence is undoubtedly at the origin of the low rate of star formation by acting against gravitational collapse in the manner of a turbulent pressure. In the solar wind, where the turbulent Mach number is less than unity, it is recognized (Bandyopadhyay at al., 2020) that compressible turbulence can provide an additional source of heating and help us to understand why the (ion) temperature decreases so slowly with heliocentric distance. This is a long-standing problem that I have been working on for 15 years (Galtier, 2018 [A77]).

Seventy years after Kolmogorov (1941), I derived the first compressible exact law for isothermal hydrodynamic turbulence (Galtier & Banerjee, 2011 [A54]). This statistical law introduces a new type of term (called source) which is purely compressible and can be interpreted as a global effect: in an expansion phase, it contributes to decrease the energy transfer rate (the intensity of the cascade), while in a contraction phase it increases the transfer rate. The exact law has been well verified numerically in 3D at turbulent Mach number 6 (Kritsuk et al., 2013). This publication paved the way for further theoretical work on plasmas (MHD) with applications to space plasmas (solar wind and Earth's magnetosphere) to better estimate the plasma heating (Banerjee & Galtier, 2013 [A58]; Hadid et al., 2018 [A75]). The most recent 3D direct numerical simulation of isothermal hydrodynamic turbulence performed at an extremely high spatial resolution of 10048^3 (Ferrand et al., 2020 [A90]), confirms that the exact law of compressible turbulence provides a relevant model to explain the observed physics. In particular, it is shown that the sonic scale separates two turbulence regimes: supersonic and sub-sonic. In the first case, we have shown that the source term of the exact law dominates, while it is the flux term in the second case. Moreover, the scaling found is dimensionally compatible with the exact law.

Gravitational wave turbulence and the primordial Universe

The first direct detection in 2015 of a gravitational wave (GW) by the LIGO-Virgo collaboration (Abbott et al., 2016), a century after their prediction by A. Einstein (1916), is certainly one of the most important events in astronomy of the last decades. This observation opens a new window onto the Universe called GW astronomy. Unlike photons, GW are expected to be unaffected by the opacity of the early Universe, therefore they have the potential to provide a wealth of observational data about this primordial phase. In modern Universe, shortly after being excited by a source like the merger of two black holes, GW become quickly linear because their amplitude decreases with the distance of propagation. The situation was probably different in the early Universe (first second) because GW were presumably significantly more nonlinear as they had much larger energy packed in a much tighter space. The nonlinear nature of the GW was pointed out in the past and the possibility to get a turbulent energy cascade of primordial GW was also mentioned but, until our work, no theory had been developed.

In Galtier & Nazarenko (2017; [A74]), we derived for the first time a turbulence theory in general relativity for an empty universe and without introducing the cosmological constant. It is a wave turbulence theory that describes a sea of weak GW interacting nonlinearly. We first proved that three-wave interactions do not contribute to the nonlinear dynamics and that the theory must therefore be developed at the level of four-wave interactions. Using the Hadad-Zakharov (diagonal) metric, we derived the kinetic equations of weak GW turbulence. These equations conserve energy and wave action for which we have a direct and an inverse cascade, respectively. We derived the exact solutions (Kolmogorov-Zakharov spectra) and showed that the inverse cascade is explosive with an anomalous scaling for the wave action spectrum during the non-stationary phase (Galtier et al., 2019 [A81]). Recently, we published the first direct evidence of a dual cascade in GW turbulence (Galtier & Nazarenko, 2021 [A96]). This result is based on a direct numerical simulation of Einstein's equations. A dual cascade of energy and wave action is reported with – as expected – a timescale corresponding to four-wave interactions. We show that wave turbulence becomes strong at large scales with a selective amplification of the space-time metric components during the inverse cascade. Strong/weak GW turbulence can potentially completely change the commonly accepted picture of the early Universe and the cause of cosmological inflation (currently considered as the result of the existence of a hypothetical scalar field called inflaton). Indeed, without introducing a new ad-hoc physics, it can be shown phenomenologically that strong wave turbulence could provide a nonlinear inflation mechanism by producing a fast condensation phenomenon eventually leaving a fossile spectrum (Harrison-Zeldovich spectrum) compatible with the Planck data (Galtier et al., 2020 [A89]). This theoretical scenario can be verified by direct numerical simulations.

Origin of the anomalous dissipation in turbulence

The anomalous dissipation is defined as the non-vanishing of the mean energy dissipation at infinite-Reynolds number. This property of the turbulence theory is so fundamental that it is often called the zeroth law of turbulence (Frisch, 1995). Number of experimental or numerical results have confirmed the zeroth law (Ravelet et al., 2008). The origin of the anomalous dissipation is, however, not rigorously understood and very often semi-phenomenological argument are used like the one proposed by Taylor (1935). In the theory of Kolmogorov (1941), the anomalous dissipation is used to derive the so-called 4/5 law for incompressible hydrodynamics. This law can be generalized to other incompressible fluids as discussed above in the context of MHD (Politano & Pouquet, 1998; Galtier, 2008 [A37]). It was Onsager (1949) who actually mentioned for the first time the possible origin of an anomalous dissipation in the loss of smoothness of the velocity field in hydrodynamics. A major breakthrough was achieved by the mathematicians Duchon & Robert (2000) who derived an exact local form of the energy dissipation created by a loss of regularity in the velocity field. In particular, they derived the Onsager anomalous dissipation in terms of velocity increments. Remarkably, the expression found is closely related to the exact 4/3 law for Navier-Stokes turbulence (Antonia et al., 1997).

The immediate question for our concern is: can we also find an expression for the anomalous dissipation in incompressible MHD which shares this remarkable property. I have proved that the answer is yes (Galtier, 2018 [A78]). The mathematical developed was performed on the 3D Hall MHD equations. I was able to recover the exact law of MHD and Hall MHD (Politano & Pouquet, 1998; Galtier, 2008 [A37]) as the kernel of the anomalous expression. This result is particularly important for space plasmas because it opens the possibility to study the question of local dissipation since the expression of the anomalous dissipation does not imply an ensemble average: it is valid for individual realization and locally in space-time in the sense of distribution (Eyink, 2008). Recently, we have studied this question using data from the Parker Solar Probe which travels very close to the Sun where discontinuities are often present. Our study (David et al., 2022 [A99]) reveals that the local heating evaluated with the expression of the anomalous dissipation can be much higher that the mean heating obtained with the classical 4/3 law of MHD. We also have studied the heating of the solar wind near Jupiter where strong shocks have been measured by Voyager. Using a reduced model that generalizes the Burgers equation to MHD, it was possible to derive an exact solution and to show that the anomalous dissipation is compatible with the small viscosity/resistivity limit (David & Galtier, 2021 [A94]). In other words, we proved the zeroth law of turbulence in a reduced MHD model.

- **PUBLICATIONS (with referees)**

[A107] Gay B. & **Galtier S**.,
Gravitational Wave Turbulence: A Multiple Time Scale Approach for 4-Wave Interactions, Phys. Rev. D **109**, 083531 (2024).

[A106] David V., **Galtier S**. & Meyrand R.,
Monofractality in the Solar Wind at Electron Scales: Insights from Kinetic Alfvén Wave Turbulence, **Phys. Rev. Lett. 132**, 085201 (2024).

[A105] Galtier S.,
A Multiple Time-scale Approach for Anisotropic Inertial Wave Turbulence, J. Fluid Mech. **974**, A24 (2023).

[A104] Galtier S.,
Fast Magneto-Acoustic Wave Turbulence and the Iroshnikov-Kraichnan Spectrum, J. Plasma Phys. **89**, 905890205 (2023).

[A103] David V. & **Galtier S.**,
Locality of Triad Interaction and Kolmogorov Constant in Inertial Wave Turbulence, J. Fluid Mech. Rap. **955**, R2 (2023).

[A102] Galtier S.,
*Physics of Wave Turbulence (**BOOK**)*, Cambridge University Press, 280 pages (2023).

[A101] David V. & **Galtier S.**,
Wave Turbulence in Inertial Electron MHD, J. Plasma Phys. **88**, 905880509 (2022).

[A100] Andrés N., Sahraoui F., Huang S.Y., Hadid L. & **Galtier S.**,
About the Incompressible Energy Cascade Rate in Anisotropic Solar Wind Turbulence, Astron. & Astrophys. **661**, A116 (2022).

[A99] David V., **Galtier S**., Sahraoui F. & Hadid L.,
Energy Transfer, Discontinuities and Heating in the Inner Heliosphere Measured with a Weak and Local Formulation of the Politano-Pouquet Law, Astrophys. J. **927**, 200 (2022).

[A98] Ferrand R, Sahraoui F., **Galtier S**., Andrés N., Mininni P. & Dmitruk P.,
In-depth Numerical Study of Exact Laws for Compressible Hall MHD Turbulence, Astrophys. J. **927**, 205 (2022).

[A97] Ferrand R, Sahraoui F., Laveder D., Passot T., Sulem P.-L. & **Galtier S**.,
Fluid Energy Cascade Rate and Kinetic Landau Damping: 3D Landau-Fluid Simulation, Astrophys. J. **923(3)**, 122 (2021).

[A96] Galtier S. & Nazarenko S.,
Direct Evidence of a Dual Cascade in Gravitational Wave Turbulence, **Phys. Rev. Lett. 127**, 131101 (2021). **EDITORS' SUGGESTION.**

[A95] Andres N., Sahraoui F., Hadid L.Z., Huang S.Y., Romanellu N., **Galtier S**., DiBraccio G. & Halekas J.,
The Evolution of Compressible Solar Wind Turbulence in the Inner Heliosphere: PSP, THEMIS and MAVEN Observations, Astrophys. J. **919**, 19 (2021).

[A94] David V. & **Galtier S**.,
Proof of the zeroth Law of Turbulence in 1D Compressible MHD and Shock Heating, Phys. Rev. E. **103**, 063215 (2021).

[A93] Ferrand R, **Galtier S**. & Sahraoui F.,
A Compact Exact Law for Compressible Isothermal Hall MHD Turbulence, J. Plasma Phys. **87(2)**, 905870220 (2021).

[A92] Huang S.Y. et al.,
The Ion Transition Range of Solar Wind Turbulence in the Inner Heliosphere: Parker Solar Probe Observations, Astrophys. J. **909(1)**, L7 (2021).

[A91] Galtier S.,
Wave Turbulence: the Case of Capillary Waves (A Review), Geophys. & Astro. Fluid Dyn. **115**, 234 (2021).

[A90] Ferrand R, **Galtier S.**, Sahraoui F. & Federrath C.,
Compressible Turbulence in the Interstellar Medium: New Insights from a Hight-Resolution Supersonic Turbulence Simulation, Astrophys. J. **904**, 160 (2020).

[A89] Galtier S., Laurie J. & Nazarenko S.V.,
A Plausible Model of Inflation Driven by Strong Gravitational Wave Turbulence, Universe **6(7)**, 1 (2020).

[A88] Menu M., Petitdemange L. & **Galtier S**.,
Magnetic Effects on Fields Morphologies and Reversals in Geodynamo Simulations, PEPI **307**, 106542 (2020).

[A87] Galtier S. & David V.,
Inertial/KAW Turbulence: A Twin Problem in the Limit of Local Interactions, Phys. Rev. Fluids **5**, 44603, 1 (2020).

[A86] Andrés N., Sahraoui F., **Galtier S**., Hadid L.Z., Ferrand R. & Huang S.Y.,
Energy Cascade Rate Measured in a Collisionless Space Plasma with MMS Data and Compressible Hall MHD Turbulence Theory, **Phys. Rev. Lett. 123**, 245101 (2019).

[A85] Ferrand R., **Galtier S**., Sahraoui F., Meyrand R., Andrés N. & Banerjee S.,
On Exact Laws in Incompressible Hall MHD Turbulence, Astrophys. J. **881**, 50 (2019).

[A84] David V. & **Galtier S**.,
-8/3 Spectrum in Kinetic Alfvén Wave Turbulence: Implications for the Solar Wind, Astrophys. J. **880**, L10 (2019).

[A83] Menu M., **Galtier S**. & Petitdemange L.,
Inverse Cascade of Hybrid Helicity in Rotating MHD Turbulence, Phys. Rev. Fluids 4, 073701 (2019).

[A82] Nazarenko S.V., Grebenev V., Medvedev S. & **Galtier S**.,
The Focusing Problem for the Leith Model of Turbulence: a Self-similar Solution of the Third Kind, J. Phys. A: Math. Theo. **52**, 155501 (2019).

[A81] Galtier S., Nazarenko S.V., Buchlin E. & Thalabard S.,
Nonlinear Diffusion Models for Gravitational Wave Turbulence, Physica D **390**, 84 (2019).

[A80] Andrés N., Sahraoui F., **Galtier S**., Hadid L.Z., Dmitruk P. & Mininni P.,
Energy Cascade Rate in 3D Compressible and Isothermal MHD Turbulence, J. Plasma Phys. **84(4)**, 905840404 (2018).

[A79] Meyrand R., Kiyani K.H., Gürcan O. & **Galtier S**.,
Coexistence of Weak and Strong Wave Turbulence in Incompressible Hall MHD, Phys. Rev. X **8**, 031066 (2018).

[A78] Galtier S.,
On the Origin of the Energy Dissipation Anomaly in Hall MHD, J. Phys. A: Math. Theo. **51**, 205501 (2018).

[A77] Galtier S.,
*Turbulence in Space Plasmas and Beyond (**INVITED REVIEW**)*, J. Phys. A: Math. Theo. **51**, 293001 (2018).

[A76] Andrés N., **Galtier S**. & Sahraoui F.,
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