

Stage Master 2

Turbulence in planet forming disks

Laboratoire J.-L. Lagrange
Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS

1 Contexte du stage

Turbulence is playing a key role in planet forming disks. It modifies the dust drift toward the star, the grains relative velocity and therefore their possible growth, turbulence can also form dust clump that may gravitationally collapse and transport angular momentum through the disk. Understanding the properties of the turbulent state in protoplanetary disk is therefore a major effort for the understanding of planet formation.

However the complex physical context of planet formation render the study of turbulence in these disks highly non trivial. The Keplerian shear tend to remove energy from the turbulent state, whereas rotation is known to elongate vertically the turbulent eddies. We have already studied particle dynamics in incompressible keplerian turbulence and identified new mechanisms participating to planetesimal formation [1, 2].

2 Objectif du stage et étapes

The aim of this internship is to provide a first characterisation of the properties of turbulence in a Keplerian flow when a weak compressibility is considered. The student will run and analyse the results of numerical simulations of forced turbulence in a Keplerian flow. The student will develop a physical understanding of process involved in the turbulent cascade of such astrophysical flows.

The different step envisioned for this project are :

- Learn to use the solver of the Navier-Stokes equation in Keplerian flows
- Run first numerical simulation in 2D, adapt and/or develop scripts to analyse the data to provide a physical comprehension
- Start to explore the parameter space (such as forcing or sound speed)

Based on the first results, several paths could be followed afterwards, including :

- Expand the parameter space to explore new physical processes
- Perform 3D simulations to start to consider the turbulent cascade in 3D
- Study the dynamics of particles in the weakly compressible turbulent flow

Students interested either in the physical processes in turbulent flows and/or protoplanetary disks are encouraged to apply. The internship will take place in the planetary science team of Lagrange laboratory in a group working on astrophysical fluid dynamics. The student will have access to the laboratory's as well as the team's weekly seminars.

Compétences

- Turbulence
- Proficiency in Python
- Interest for astrophysics and numerical simulations
- Autonomy and ability to work in an interdisciplinary context

Contacts

— Héloïse Méheut : heloise.meheut@oca.eu

Références

- [1] Fabiola Antonietta GEROSA, Héloïse MEHEUT et Jérémie BEC. “Clusters of heavy particles in two-dimensional Keplerian turbulence”. In : *EPJPlus* 138.1 (jan. 2023), arXiv :2210.13147. ISSN : 2190-5444. DOI : 10 . 1140/epjp/s13360-022-03585-8. URL : <https://ui.adsabs.harvard.edu/abs/2022arXiv221013147G>.
- [2] Fabiola Antonietta GEROSA et al. “Reduction of dust radial drift by turbulence in protoplanetary disks”. In : *A&A* 685, L4 (2024) 685, arXiv :2404.11544 (17 avr. 2024), p. L4. ISSN : 1432-0746. DOI : 10 . 1051/0004-6361/202449660. arXiv : 2404 . 11544 [astro-ph.EP]. URL : <https://ui.adsabs.harvard.edu/abs/2024arXiv240411544G>.