Postdoc position

Wave kinetic description of anisotropic systems: recovery of isotropy and stability

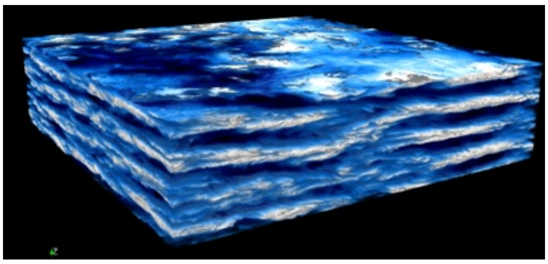
Duration: 1 year**,** starting no later than September 2024
Institution: Laboratoire J.L. Lagrange. Observatoire de la Côte d'Azur. Nice, France.
Funding: Simons Foundation international collaboration project "Wave Turbulence".
Contact: Giorgio Krstulovic (https://www.oca.eu/krstulovic)
Sergey Nazarenko (https://inphyni.cnrs.fr/webpages/sergey-nazarenko)
Deadline for application: 30/05/2024

The project:

Waves are one of the most ubiquitous phenomena in nature. Wave systems are so diverse that they vary from the simplest everyday acoustic sound propagation to internal and inertial waves in the oceans and atmospheres, waves in quantum fluids, Alven waves in plasmas and many more.

In general, the equations of motion that describe wave systems are not linear, which makes wave dynamics rich, complex and interesting. Waves with different wavelengths interact and excite new waves at different scales, which will again interact with other waves and repeat the process at different scales. In this manner, non-linear wave systems can transfer energy along scales in a cascade process, leading what we know as wave turbulence. Such complex physics can, fortunately, be understood using the theory of weak wave turbulence. This theory is able to provide analytical predictions for the mean amplitude of waves at different scales, and explain and predict the energy cascade and the evolution of different statistical quantities.

More specifically, the wave turbulence theory furnishes a wave kinetic equation (WKE), analogous to the Boltzmann equation, but where waves at different wave numbers play the role of particles. The rigorous derivation of the WKE, its applications and its predictions have triggered important multi-disciplinary research among mathematicians and theoretical and experimental physicists [1].



Internal waves in a stratified fluid. Simulation made at the Fluid and Plasma Turbulence group of Laboratoire J.L. Lagrange.

Enormous progress has been achieved recently in understanding the wave turbulence theory for several systems, particularly when the system is isotropic. Unfortunately, nature is hardly isotropic, and the theory needs to be revised and adapted in such cases. For instance, oceans are typically stratified and exhibit an almost constant density gradient with deepness. For example, the figure shows the density fluctuations in a turbulent stratified fluid. Another example is the atmospheres of some

[1] See for instance the SIMONS Collaboration Wave Turbulence https://cims.nyu.edu/wave-turbulence/

planets, where the effect of planet rotation is important. Both systems admit waves propagating peculiarly, in which the dynamics are completely anisotropic.

This Postdoc project aims at understanding the propagation of weakly nonlinear waves in anisotropic media. The isotropy of the system will emerge either from external sources (forcing) or might be intrinsic to the waves due to the physics of the problem. **The main questions to understand is how non-linear wave interactions helps to recover isotropy and the stability of certain out-of-equilibrium solutions**. The scientific problem will be addressed using the wave turbulence theory and studying solutions of the associated wave kinetic equations. To complement theoretical predictions, the successful applicant will perform numerical simulations of the wave kinetic equation and the original dynamical equation describing the whole physics. This postdoc position is, therefore, theoretical with an important numerical part using existent numerical codes.

Applicant profile:

Applicants should have some background in fluid mechanics and numerical methods. A good general knowledge of statistical physics and mathematical methods for physics will be appreciated. Additionally, the postdoc researcher will gain knowledge in high-performance computing (HPC) and develop expertise in non-linear physics, statistical mechanics, and fluid mechanics.

Research environment:

The successful applicant will join the team led by Giorgio Krstulovic (https://gkrstulovic.gitlab.io), a CNRS researcher at the Fluid and Plasma Turbulence group of Laboratoire J.L. Lagrange hosted by Observatoire de la Côte d'Azur (https://www.oca.eu/en/fluid-home). The group comprises experts in classical and quantum turbulence, magnetohydrodynamics, plasmas, particle transport, applied mathematics and computational fluid dynamics. The successful applicant will also take advantage of already established international collaborations of the group.

In addition, this project will carried out in close collaboration with Sergey Nazarenko from Institut de Physique de Nice, also a member of the SIMONS Collaboration.

Enquiries and Application Process

To apply for this postdoc position or enquire about the project, please contact Giorgio Krstulovic (krstulovic_at_oca.eu) in the first instance.

Additional information

The successful applicant will be part of the SIMONS Collaboration Wave Turbulence. Giorgio Krstulovic and Sergey Nazarenko are both members of this international collaboration. The postdoc researcher will be in a rich environment where experts from different countries meet regularly.