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Introduction

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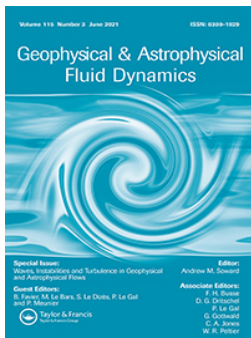
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INTRODUCTION



This special issue includes some of the many contributions and lectures given at the “Waves, Instabilities and Turbulence in Geophysical and Astrophysical Flows (WITGAF)” summer school and workshop held at the Institut d’Etudes Scientifiques de Cargèse (Corsica, France) from 8 to 19 of July 2019 (<https://witgaf2019.sciencesconf.org/>). This meeting was the third iteration of a series traditionally organised by researchers from the Institut de Recherche sur les Phénomènes Hors Equilibre of Marseilles. The first in the series took place in Porquerolles in May 2009, while the second in Les Houches in February 2013.

Understanding the dynamics of geophysical and astrophysical systems, such as oceans, atmospheres, planetary cores, stellar interiors, accretion disks, remains a tremendous interdisciplinary task. Beyond the challenge in fundamental fluid mechanics to understand these extraordinary flows involving rotation, buoyancy, magnetic fields, at typical scales, which are evidently well beyond our day-to-day experience, a global knowledge of the fundamental processes involved is needed to better understand the dynamics of these systems.

Much research effort has been devoted to understanding geophysical and astrophysical flows, within and between the various communities of Mechanics, Applied Mathematics, Engineering, Physics, Planetary and Earth Sciences, Astrophysics, and so on. Significantly, open questions from the various applications rely on the same fundamental concepts and phenomena. Though much progress has been made within each discipline, there has only been marginal cross-fertilisation, a situation the workshop aimed to improve. Our goal was to bring together researchers interested in various branches of geophysical and astrophysical fluid dynamics, and, for both students and mature researchers, provide the necessary underlying fundamental fluid mechanics background as well as outline the latest research

developments on waves, instabilities and turbulence in the contexts of oceans, atmospheres, planetary cores, stellar interiors and accretion disks.

We think that we have achieved our objectives and that the hundred or so participants and speakers have benefited from the courses, discussions and exchanges that took place from the amphitheatre to the Corsican beaches. The present issue gives a flavour of the diversity of the different contributions and subjects discussed during the “WITGAF” meeting.

The very large scales of the universe were described by S. Galtier who explained to the attendees the concept of turbulence of gravitational waves in the primordial universe. However, wave turbulence is ubiquitous in nature: from the surface waves of the oceans to internal waves in the atmosphere and S. Galtier presents here the derivation of the fundamental concepts of wave turbulence and its kinetic equation on the tractable example of surface capillary waves.

On the smaller scale of a single planet, Y. Lin and J. Noir present here new numerical simulation results about inertial waves and their nonlinear interactions that occur in planetary cores or the subsurface oceans when these undergo forcings by libration due to gravitational interactions with orbital companions. Their direct numerical simulations show, in particular, the emergence of mean zonal flows and internal shear layers. These should be relevant to the dynamics of planetary interiors, because the authors establish that the calculated amplitudes grow when the Ekman number decreases.

Also interested by planetary core dynamics, K. Lam, D. Kong and K. Zhang address in their article the problem of thermal convection under weak precession in a rapidly rotating, self-gravitating, internally heated fluid sphere. Their numerical simulations show that the competition between the two kinds of forcing leads to the emergence of a never seen before localised wave travelling in the azimuthal direction.

In the work of G. Meletti *et al.*, numerical simulations are complemented by laboratory experiments on the Strato-Rotational Instability (SRI) making the rotating shear flow unstable in regions where – without stratification – it would be stable. As proposed in their article, this characteristic renders SRI a relevant phenomenon in planetary and astrophysical applications, particularly in the magnetically dead zones of accretion disks.

On the contrary, ionised disks are subject to the Magneto-Rotational Instability (MRI) that is studied here by Y. Bai *et al.* using a subtle analogy between the instability of viscoelastic Taylor-Couette flow in the Keplerian regime and the MRI of conducting magnetic fluids. Inversely, the present results allow to use the Velikhov-Chandrasekhar criterion of the MRI to predict the elasto-rotational instability (ERI) observed in their experiment.

A typical example of atmospheric dynamics is then discussed by M. Rostami and V. Zeitlin who show in their article that large-scale slowly eastward-moving twin-cyclone coherent structures, called “modons”, are robust solutions of both the one and two layer versions of the rotating shallow water model on the equatorial β -plane. These modons show interesting and relevant features that might be related to the Madden-Julian Oscillation events of the tropical atmosphere.

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