



Topological Waves in Astrophysical and Geophysical Flows

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Over the last decade, the concept of topological wave has spread over all fields of physics. These ideas were initially developed in condensed matter to describe peculiar electronic transport properties in exotic materials; it has now become clear that topological tools apply as well to classical systems, and thus to geophysical fluid dynamics. Topology predicts the emergence of unidirectional modes trapped along interfaces or boundaries, depending on broken discrete symmetries, and on the twisting of bulk eigenmodes. It guarantees the robustness of unidirectional trapped modes against disorder, such as random topography or small scale turbulence. We will explain how to compute such topological features, discuss possible experimental realizations, and present three recent applications to geophysical flows :

- The emergence of equatorially trapped topological modes in Laplace tidal equations as a consequence of Coriolis force breaking time-reversal symmetry **[1,2]**.
- The emergence of Lamb-like waves that connect acoustic wave bands to internal gravity waves bands in compressible-stratified fluids, as a consequence of gravity breaking mirror symmetry, with potential applications in helioseismology **[3]** .
- A new manifestation of these topological features in geophysical ray tracing : when computing first order corrections to ray tracing, we find that rays or wave packets are deflected by an effective field corresponding to the so-called Berry curvature. To our knowledge, the effect of this Berry curvature had up to now been overlooked in geophysical context **[4]**.

[1] P. Delplace, J.B. Marston, A. Venaille, *Topological origin of equatorial waves*, **Science** **2017**

[2] C. Tauber, P. Delplace, A. Venaille, *A bulk-interface correspondence for equatorial waves*, **Journal of Fluid Mechanics** **2019**

[3] M. Perrot, P. Delplace, A. Venaille, *Topological transition in stratified fluids*, **Nature Physics** **2019**

[4] N. Perez, P. Delplace, A. Venaille *Manifestation of Berry curvature in geophysical ray tracing*, **in prep.** **2020**

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