Novel statistical tools to characterize interstellar magnetized turbulence.

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The structures of matter formed in the interstellar medium are the result of a complex interplay of physical processes, acting on many connected spatial and temporal scales. Among these processes, magnetized turbulence is thought to play a major role, and numerical simulations are now able to reproduce qualitatively the complex, filamentary structures observed, e.g., in thermal dust emission, but the non-linear nature of the processes at work hinders our ability to precisely compare these simulations to observations and thus assess the characteristics of interstellar turbulence.

To overcome this difficulty, we have initiated a collaboration with data scientists who have developed an analysis framework, the wavelet scattering transform (WST), which is able to capture the essential statistical properties in any given image, beyond the standard power spectrum estimation [1]. Applying the WST to numerical simulations of interstellar turbulence with various levels of turbulent forcing and magnetic field intensity, we demonstrate that it is able to efficiently discriminate between different physical settings, even though the structures appearing in these simulations look very similar to the naked eye.

The WST thus promises to open a fruitful new avenue of research to quantitatively assess the properties of magnetized interstellar turbulence based on a morphological analysis of the structures appearing in emission maps.

Références

[1] Bruna J. & Mallat S., IEEE Transactions on Pattern Analysis and Machine Intelligence, 35, 8 (2013)