A First Analysis of Turbulence in Molecular Clouds in the Triangulum Galaxy (M33)

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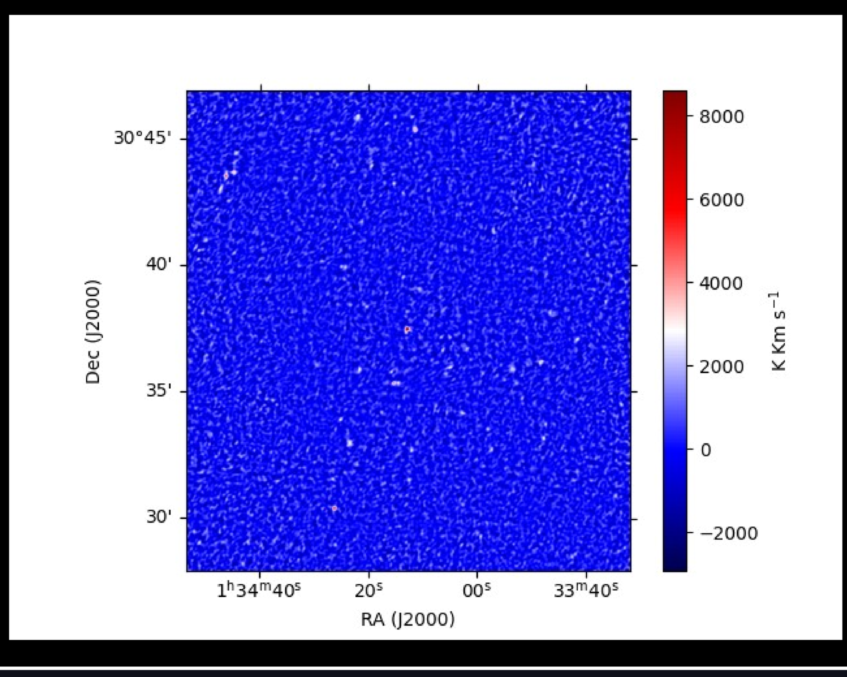
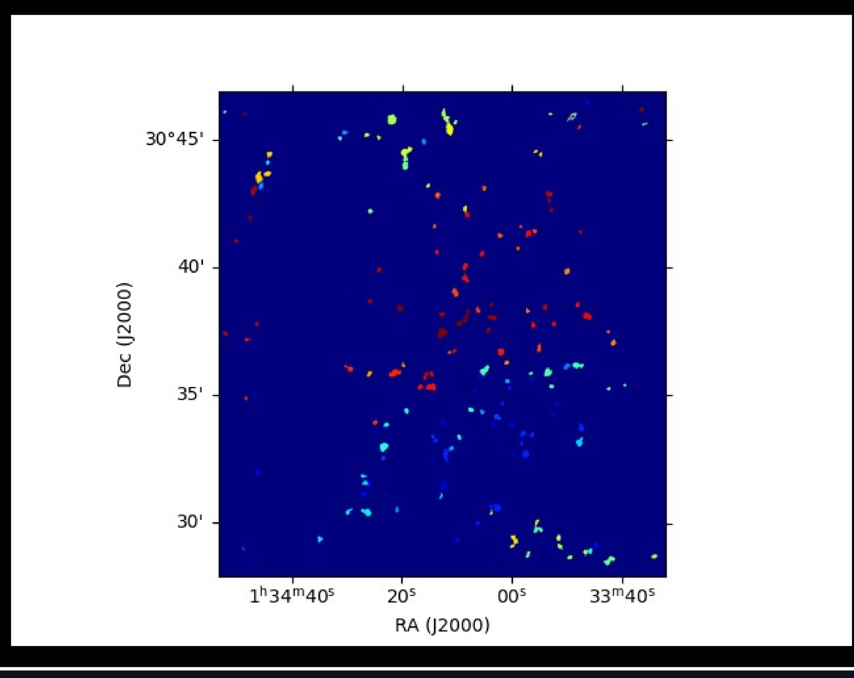
The nature of turbulence in molecular clouds is one of the driving factors that influence the efficiency by which the gas is converted to stars. In the Milky Way, it is speculated that the high star formation efficiency observed in spiral-arm clouds is linked to the prevalence of compressive curl-free) turbulent modes in the motion of molecular gas, while the shear-driven solenoidal (divergence-free) modes appear to be the main cause of the low star formation efficiency that characterizes clouds in the Central Molecular Zone. We proved the inverse proportionality between the solenoidal and the star formation efficiency in the plane molecular clouds in the Milky Way in the CHIMPS survey and, in addition, that the solenoidal modes decrease with a shallow gradient with the distance from the centre of the Galaxy. This shallow gradient is unaffected by the presence of spiral arms. In this investigation, we perform a similar analysis of turbulence on a sample of clouds spanning all galactic environments in the Triangulaum galaxy (M33). At a distance of 840 kpc with its nearly face-on inclination, M33 is an ideal target to probe how large-scale mechanisms affect gas motions in giant molecular clouds, thus impacting the clouds' evolutionary state and star forming efficiency. Using ACA and ACA+IRAM observations of $^{13}CO(2\text{-}1)$ and $^{12}CO(2\text{-}1)$ molecular lines, we explore how solenoidal turbulence varies with galactocentric distance and within various galactic features.

^{13}CO sources

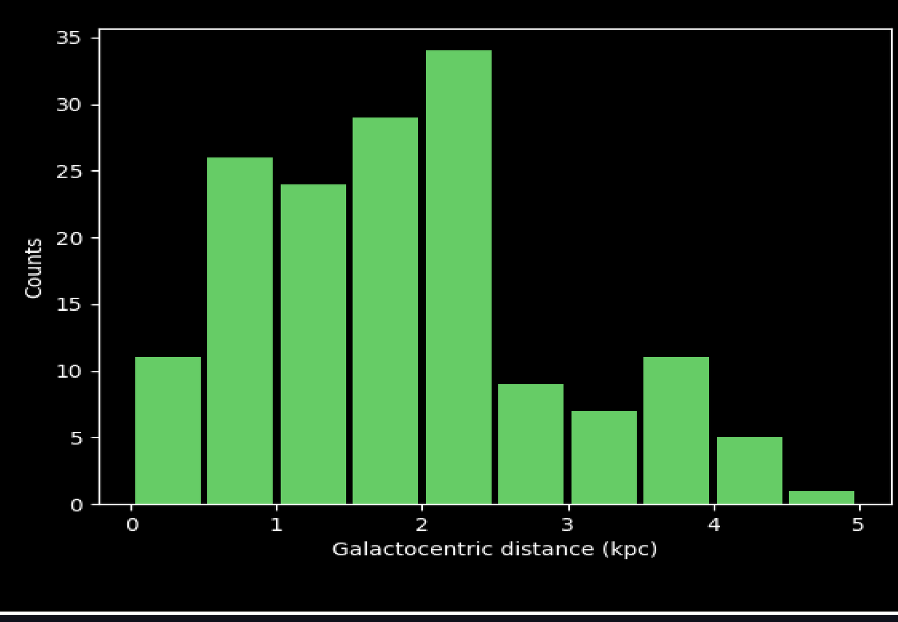
Emission



PyCPROPS extraction

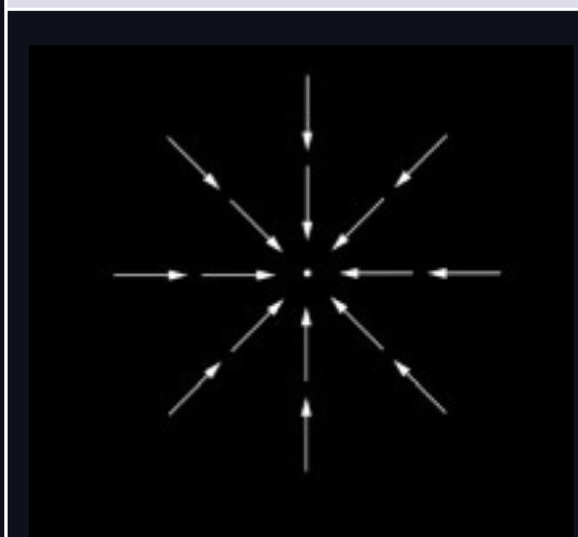


Distribution

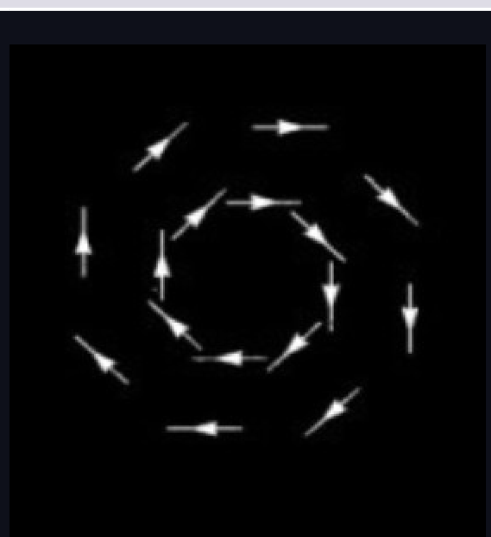


- ACA observed ^{13}CO emission with resolution of 30 pc
- 158 $^{13}CO(2\text{-}1)$ sources identified by PyCPROPS
- Minimum size: 4x4x2 voxels in ppv space
- Each source is matched to $^{12}CO(2\text{-}1)$ emission

Solenoidal fraction



Compressive



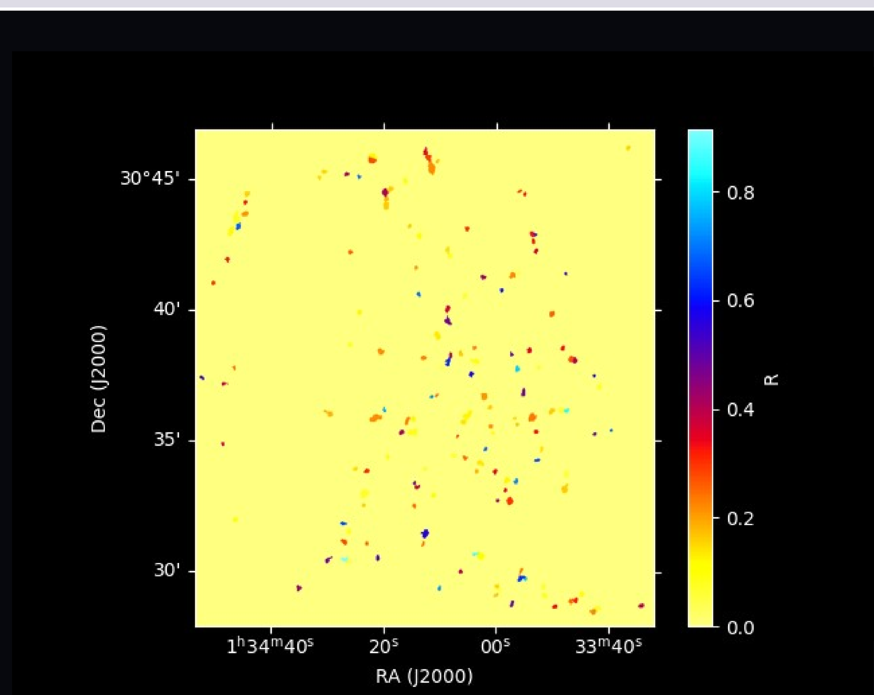
Solenoidal

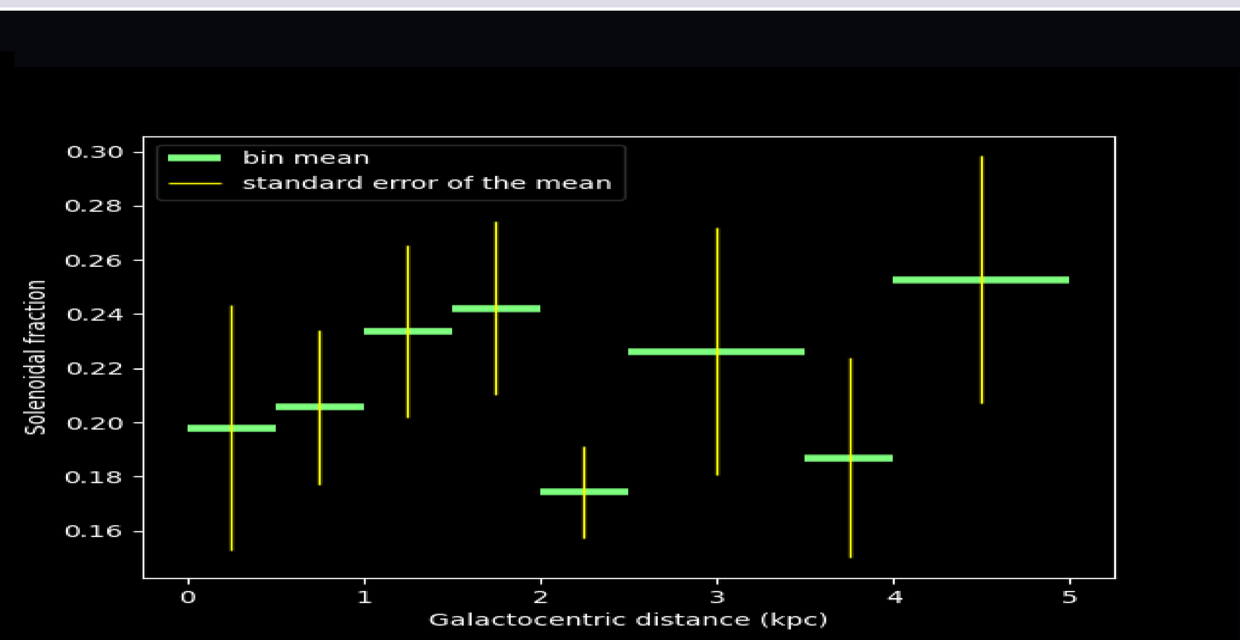
We consider the density momentum field defined as **p** = ϱ**v** (product of volume density and velocity). The solenoidal fraction, R, is the relative amount of power in the solenoidal mode of the turbulence in the **p** field and is defined as the ratio of the variance of the line-of-sight projected transverse momentum the variance of total momentum,

$R = \sigma^2_{p\perp} / \sigma^2_p$.

The solenoidal fraction can be inferred from the projected observable emission in a position-position-velocity cube through its velocity-weighted moments and azymuthally average the power spectra of the moment maps.

Different environments





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