The atomic envelope of molecular clouds as revealed by machine vision

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The Physics and Chemistry of the Interstellar Medium
Avignon, France. September 2-6, 2019
Structure of photodissociation regions

Idealized molecular clouds

CO
Idealized molecular clouds

Less-idealized molecular cloud

Goodman, A. HHSF2018
Proof of concept: histogram of relative orientations (HOG)


HI (THOR)  

\[ 1^\circ 00' \]

\[ 0^\circ 30' \]

\[ 00' \]

\[ -0^\circ 30' \]

\[ -1^\circ 00' \]

Galactic Longitude

35°00' 34°40' 20' 00'

13CO (GRS)  

Galactic Longitude

35°00' 34°40' 20' 00'
Proof of concept: histogram of relative orientations (HOG)


HI (THOR)

13CO (GRS)
Histogram of oriented gradients (HOG)
Histogram of relative orientations (HOG)
Histogram of relative orientations (HOG)

Histogram of relative orientations (HOG)

Histogram of relative orientations (HOG)

Histogram of relative orientations (HOG)


\[ V = \frac{\sum_k^N w_k \cos 2\phi_k}{\sqrt{\sum_k^N (w_k)^2 / 2}} \]

\[ AM = \left\langle 2 \cos \phi_{ij} - 1 \right\rangle_{ij} \]

\[ V = 143.0 \]

\[ AM = 0.35 \]
Spatial correlation


Image group A

0.

1.

2.

Image group B

0.

1.

2.
Spatial correlation between HI and $^{13}$CO

Spatial correlation between HI and $^{13}$CO

Spatial correlation between HI and $^{13}$CO


$I^{HI}(55.0 \text{ km s}^{-1}), I^{13CO}(56.3 \text{ km s}^{-1})$
Spatial correlation between HI and $^{13}$CO

HI self-absorption (HISA)


WNM

$N = 6 \times 10^{20}$
$T = 1000 \text{ K}$
$\Delta V = 10$
$V = 0$
$\tau_{pk} = 0.03$

CNM

$N = 1 \times 10^{20}$
$T = 20 \text{ K}$
$\Delta V = 1.5$
$V = 2.0$
$\tau_{pk} = 1.72$

$T_b (K)$

$V (\text{km s}^{-1})$

(a) (b)
HISA and $^{13}$CO

Spatial correlation between HI and $^{13}\text{CO}$

Spatial correlation between HI and $^{13}$CO

Spatial correlation between HI and $^{13}$CO

Synthetic observations of a collision of atomic clouds

Spatial correlation between HI and $^{13}$CO


MHD sims:
Spatial correlation between HI and $^{13}$CO

HISA and $^{13}$CO

We found a #MorphologicalCorrelation between the HI and $^{13}$CO emission using #HOG, a tool from #MachineVision.

The #MorphologicalCorrelation is found in velocity channels with $v_{\text{HI}} \approx v_{\text{CO}}$, but also in channels separated by a few km/s, particularly toward #HIIregions.

We are using this #StatisticalTool to systematically study other regions in the Galactic plane and study #SyntheticObservations of stellar feedback #MHDsims.

Tools and data available at:
https://github.com/solerjuan/astrohog
http://www.mpia.de/thor
Extra Slides
From gas to stars

Molecular clouds

Cold atomic gas

Warm atomic gas

Stars
Histogram of relative orientations (HOG)


V = 217.0
AM = 0.49

V = 16.4
AM = 0.28

V = 16.2
AM = 0.28
HOG statistical tests - Montecarlo sampling

From diffuse gas to molecular clouds

Hennebelle & Iffrig, 2014, 2015
Hennebelle, 2018

RAMSES simulation
L = 1 kpc (up to 2x10^{-3} pc resolution)
Turbulence driven by SNe

Hennebelle & Iffrig, 2014, 2015
Hennebelle, 2018

From diffuse gas to molecular clouds

FRIGG simulations - synthetic observations

From diffuse gas to molecular clouds