Cataloguing substructure in Star Forming Regions

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Objective

Construction of a catalog of substructure in star forming regions allowing for comparison of the substructure characteristics amongs different regions

Substructure Catalog
- Reliable
- Homogeneous

Methodology for detection
- Reliable
- Homogeneous
- Robust to different inputs
The procedure

DBSCAN

MinPts = 4

PARAMETERS
Epsilon
MinPts

Multiplicity and clustering in Taurus star-forming region
I. Unexpected ultra-wide pairs of high-order multiplicity in Taurus
Isabelle Joncour\textsuperscript{1,2}, Gaspard Duchêne\textsuperscript{1,3}, and Estelle Moraux\textsuperscript{1}

Multiplicity and clustering in Taurus star forming region
II. From ultra-wide pairs to dense NESTs\textsuperscript{*}
Isabelle Joncour\textsuperscript{1,2}, Gaspard Duchêne\textsuperscript{1,3}, Estelle Moraux\textsuperscript{1}, and Frédérique Motte\textsuperscript{1}
Choosing epsilon

Compare the sample with complete spatial randomness

One point correlation function

$\Psi(r) = \frac{w_{samp}(r)}{w_{rand}(r)}$

$w$ is the first nearest neighbour density

$w_{rand}(r) = 2\pi \rho r \exp(-\pi \rho r^2)$

Local density from the mean 6th nearest neighbour distance
Choosing $N_{\text{min}}$

Guarantee reliability over random fluctuations

\[
    w_{\text{rand}}^n(r) = \frac{2(\pi \rho)^n}{\Gamma(n)} r^{2n-1} \exp(-\rho \pi r^2)
\]

\[
    P(n) = \int_0^\epsilon w_{\text{rand}}^n
\]

Probability of having at least $n$ neighbours within an epsilon radius for a random distribution.
Simulations

Fractal

Radial

Plummer

Structured

Homogeneous

Concentrated

Q < 0.8

Q ~ 0.8

Q > 0.8
Projection effects and homogeneous distributions

2D homogeneous

3D projected homogeneous
Ripley K function

\[ K(r) = \rho^{-1} \frac{\text{Card}\{ p_i, p_j \mid d(p_i, p_j) < r \}}{n} \]

\[ K_{\text{rand}}(r) = \pi r^2 \]

2D homogeneous

3D projected homogeneous
Radius of local homogeneity

Structured
Homogeneous
Concentrated
Locally homogeneous regions
Structured regions
Concentrated regions
Real data: Taurus
Real data: ic348
Real data: Carina Nebula

Buckner et al 2019
(ellipses: Khun et al 2014)
Summary

• Developed a robust methodology to retrieve structures on a variety of different nature inputs

• Objective, statistically-based strategies to ensure reliability and mitigate projection effects.

• Limits: single scale → density. Multiscale version already on development.