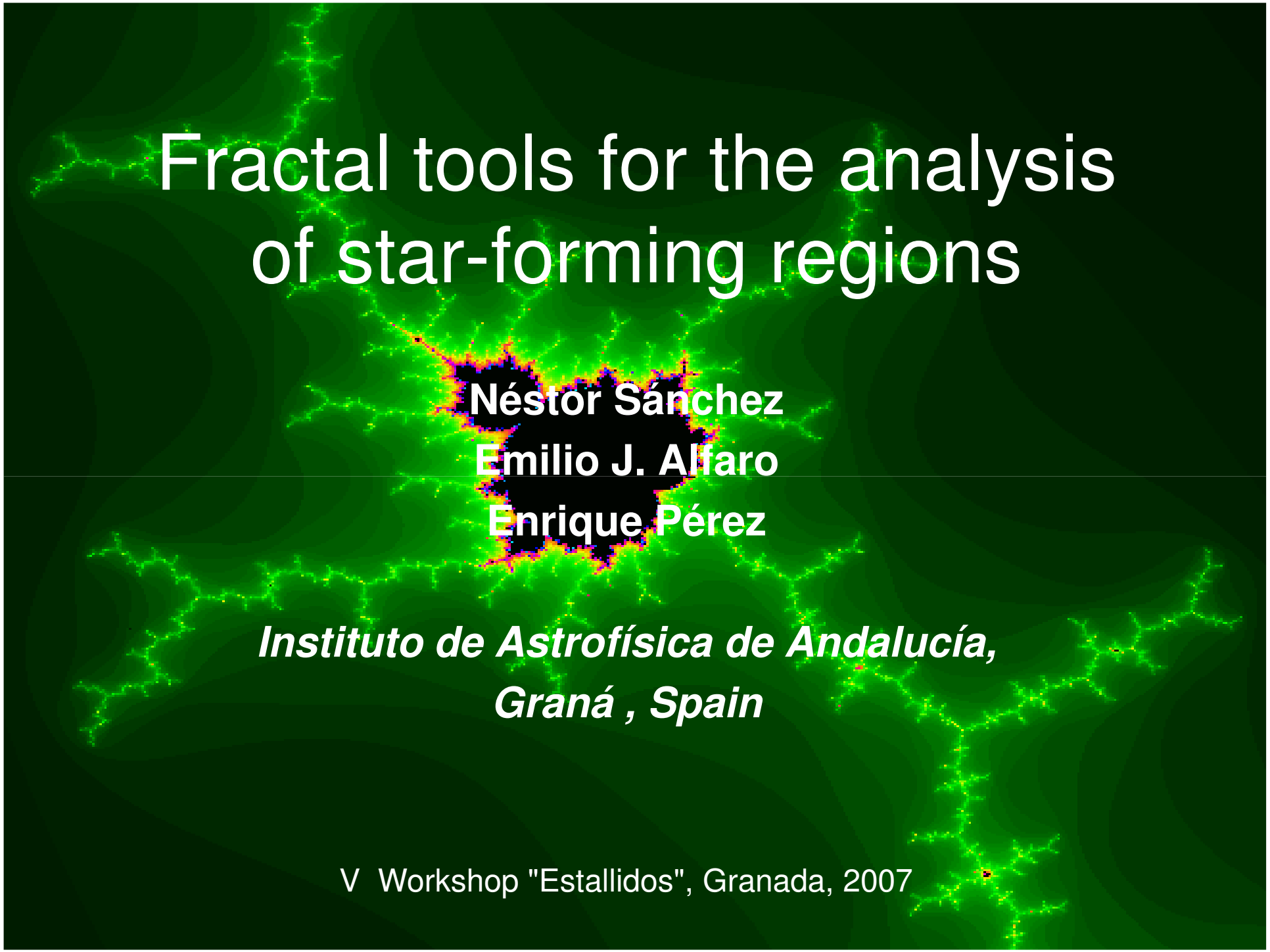


Fractal tools for the analysis of star-forming regions

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Introduction / Motivation

Star formation process.

↑

Initial conditions: ISM structure

↑

Objective/Systematic ISM characterization

↑

ISM structure vs environmental variables

↑

Our approach: ISM topology

↑

Fractal dimension (Df): degree of complexity (smoothness or clumpyness) of the ISM

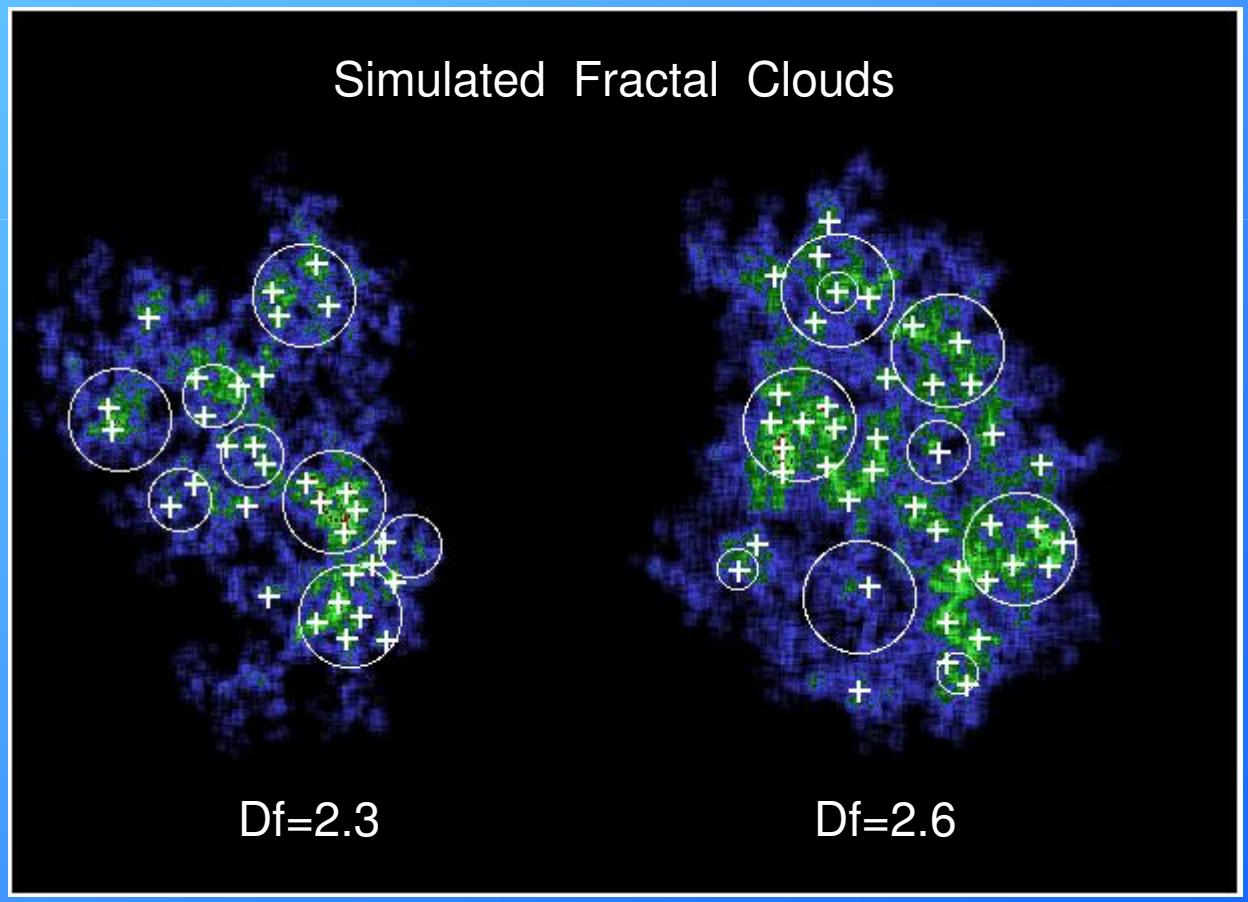
Fractal dimension estimators

$F \sim x^{Df}$

Perimeter-area: $P \sim A^{Dper/2}$

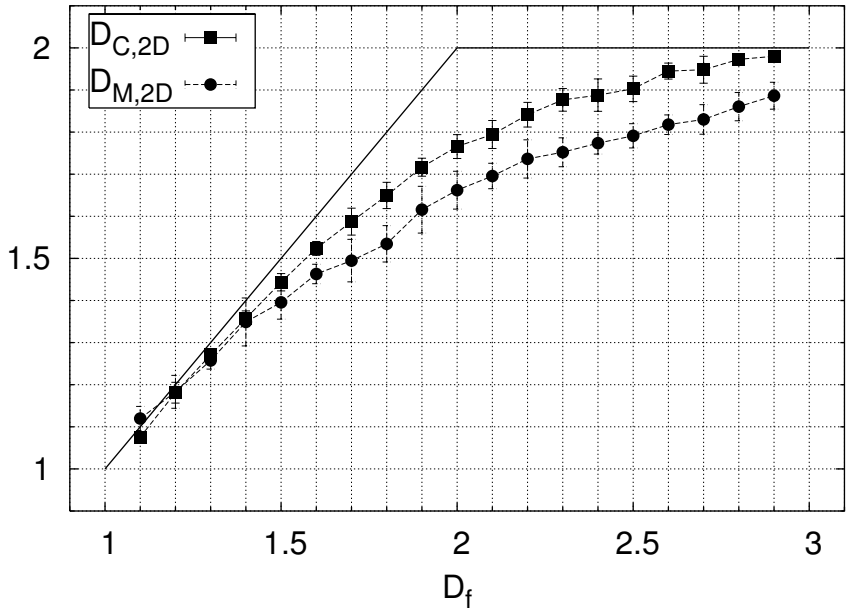
Mass-radius: $M \sim r^{Dm}$

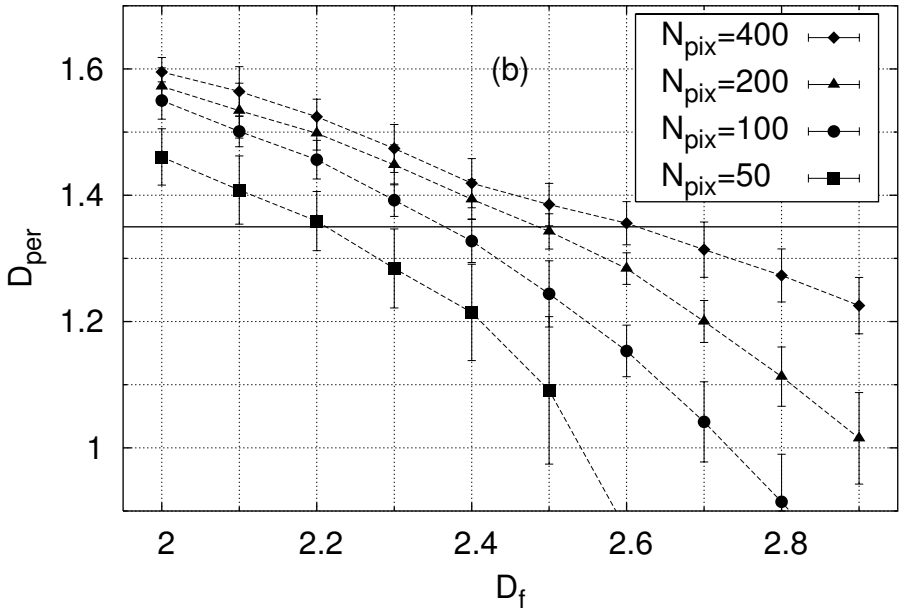
Correlation integral: $C \sim r^{Dc}$



Factors affecting the estimation of Df:

- Proyection effects
- Image resolution
- Opacity
- Noise





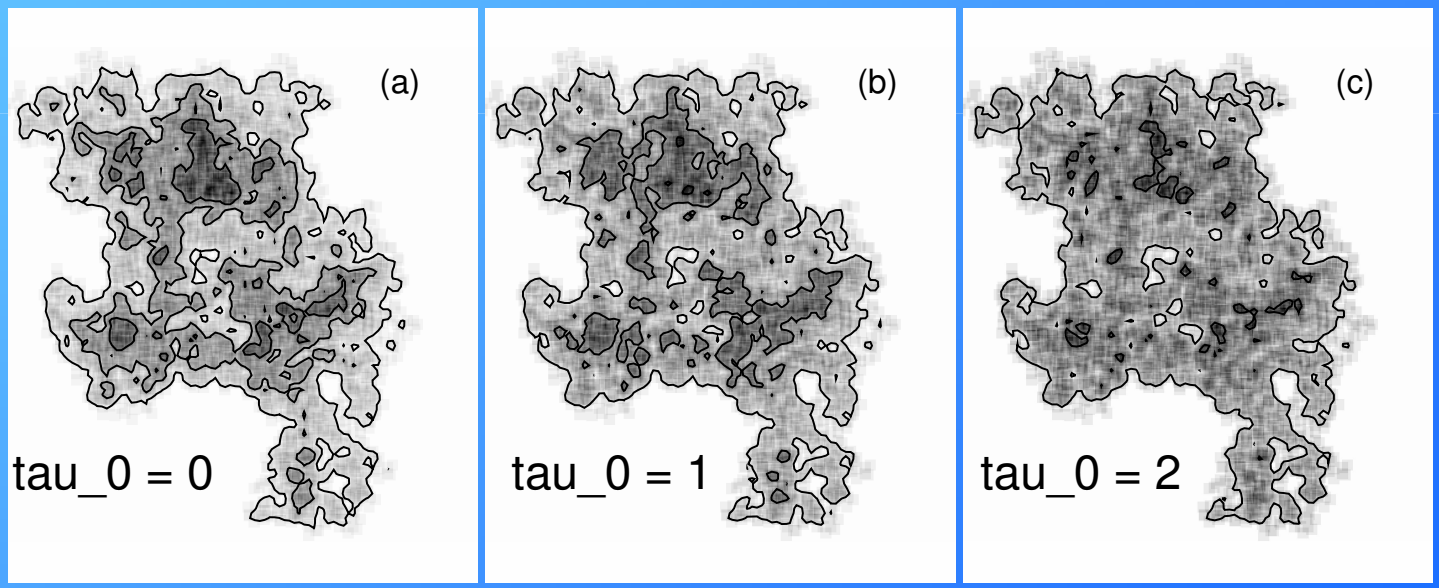
2D: Df_calcu < Df_theor

Dper = Dper(Df,Npix)

(Sanchez, Alfaro, Perez, ApJ, 2005)

Factors affecting the estimation of Df:

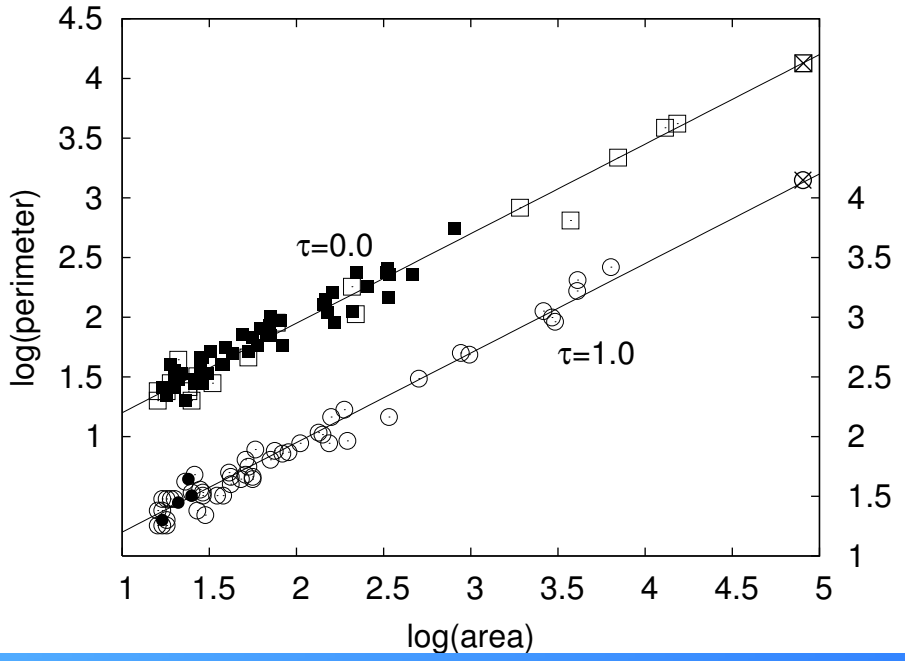
- Proyection effects
- Image resolution
- Opacity
- Noise

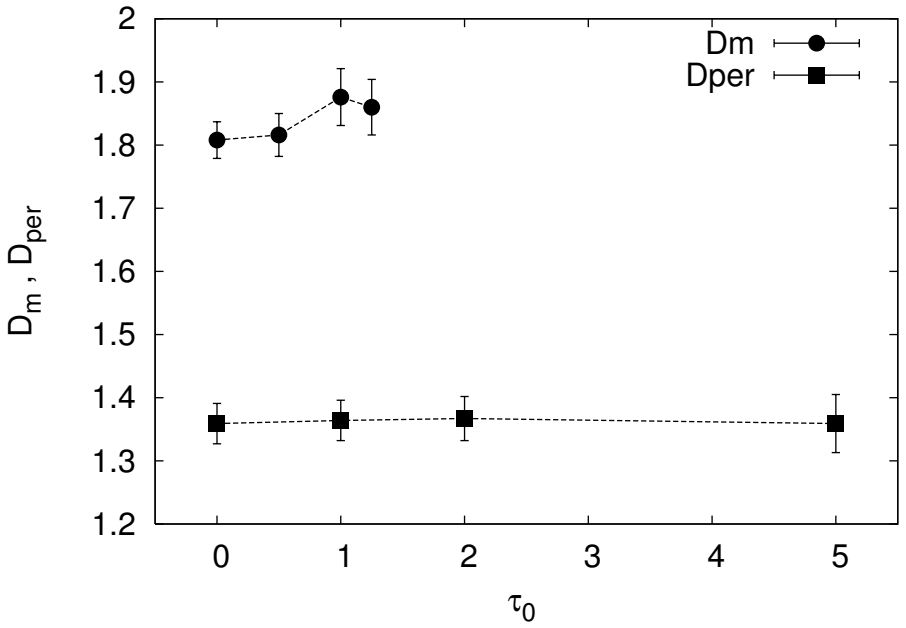


(Sanchez, Alfaro, Perez, ApJ, 2007)

Factors affecting the estimation of Df:

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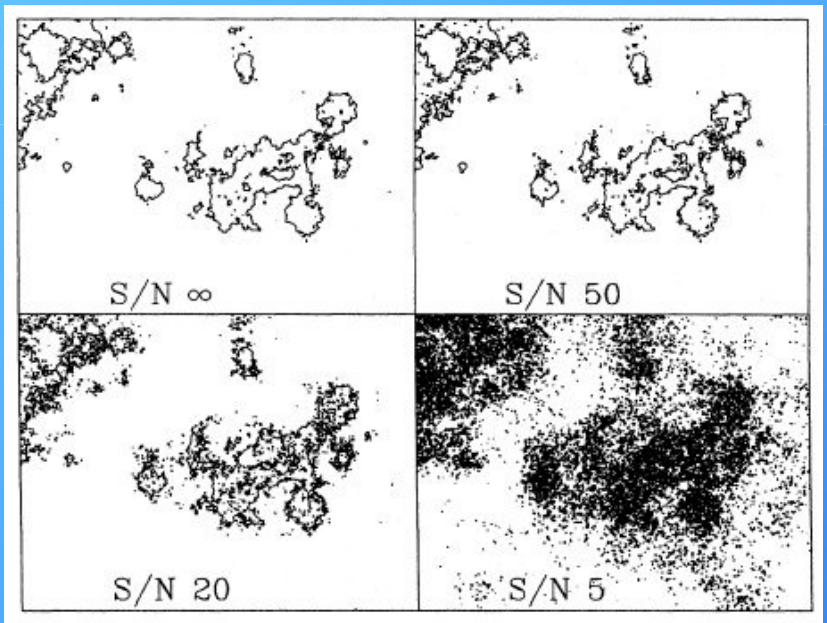


Dper ≠ Dper(tau)

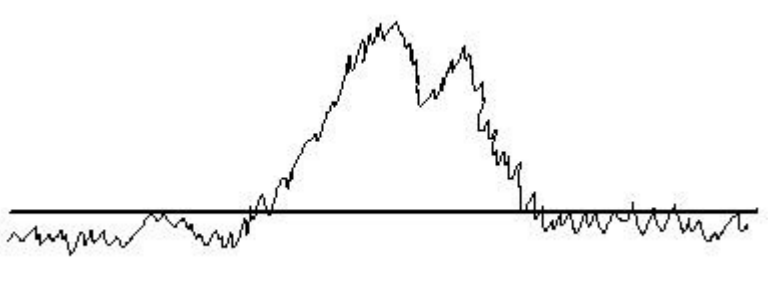
(Sanchez, Alfaro, Perez, ApJ, 2007)

Factors affecting the estimation of Df:

- Proyection effects
- Image resolution
- Opacity
- Noise



(taken from Vogelaar & Wakker 1994)

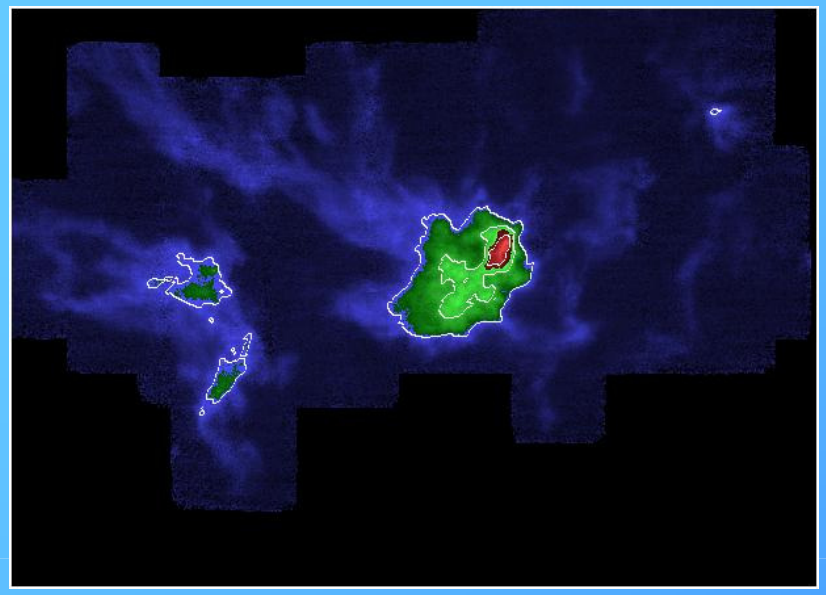


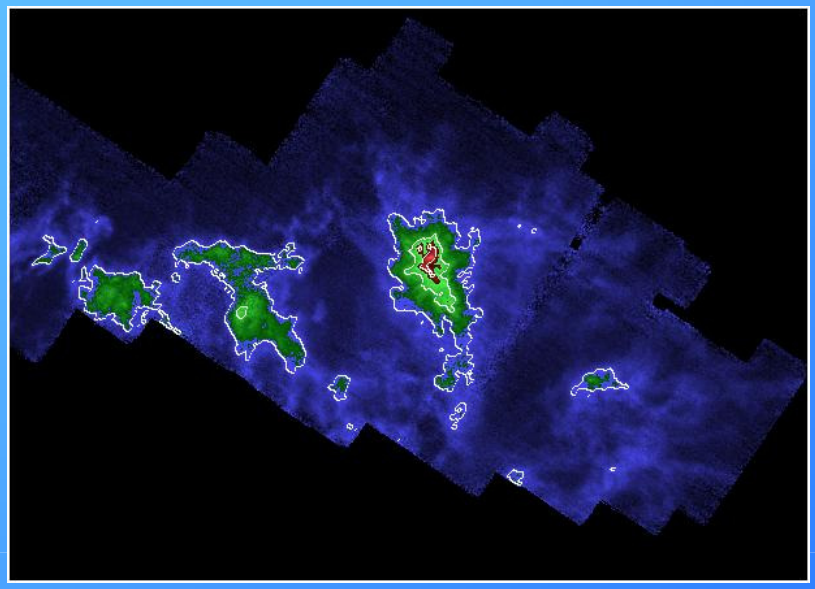
Contrast = I(max)/s.d.(background)

Recipe: Smooth the image to maximizing the contrast

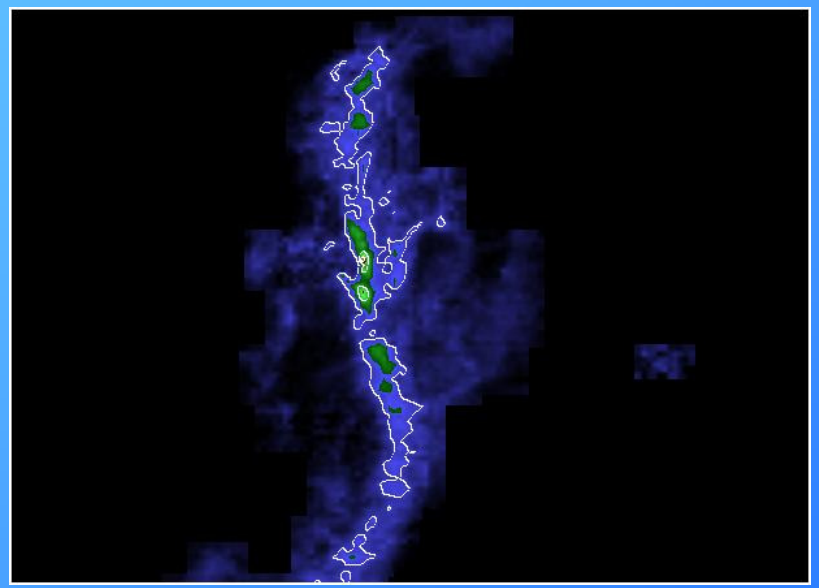
Dper_opt = Dper(max. cont.)

Application to emission maps





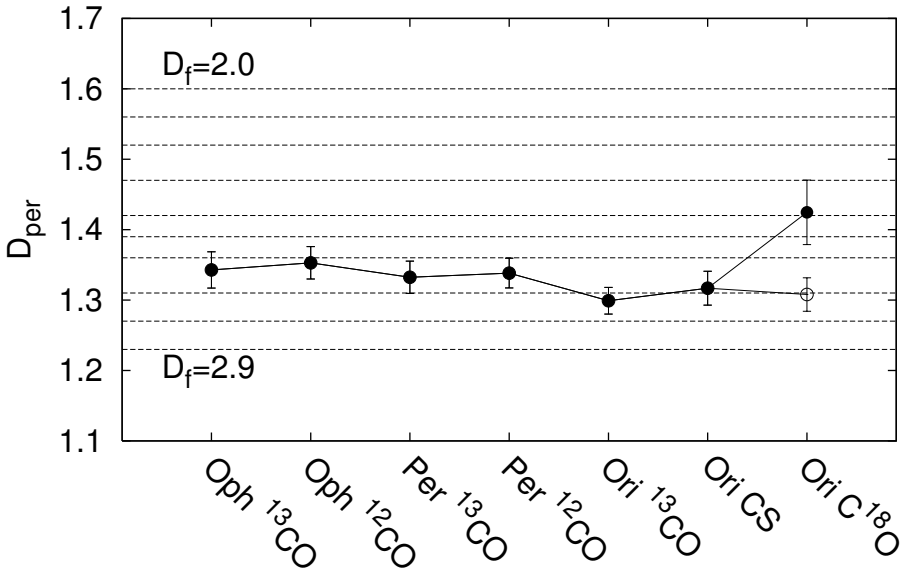
Ophiuchus, Perseus (COMPLETE, Ridge et al. 2006)

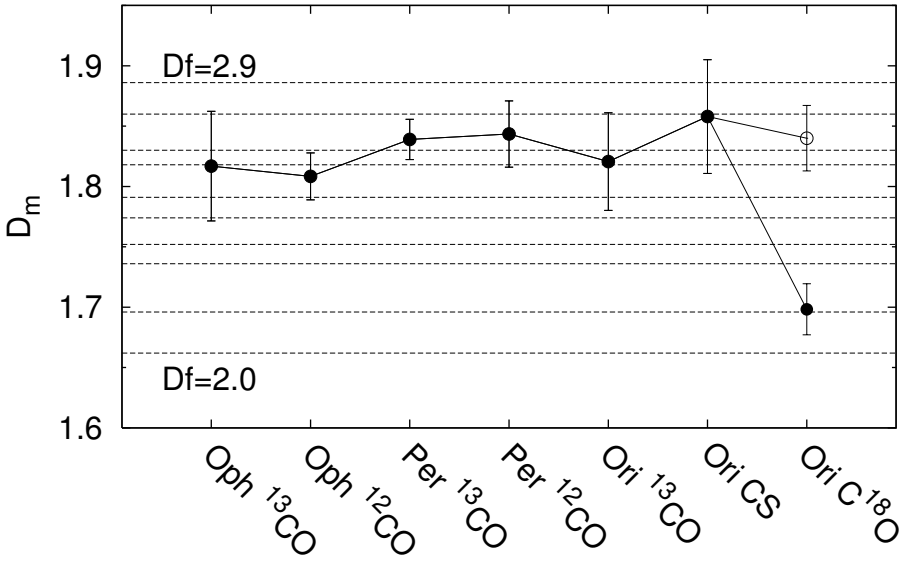


Orion (Nobeyama, Tatematsu et al. 1993)

13CO maps

Application to emission maps



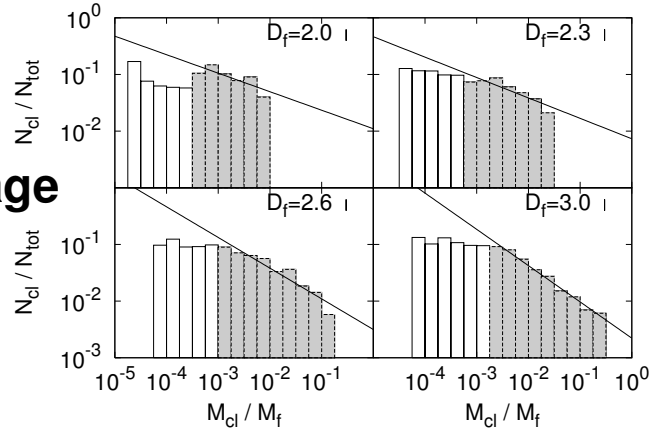


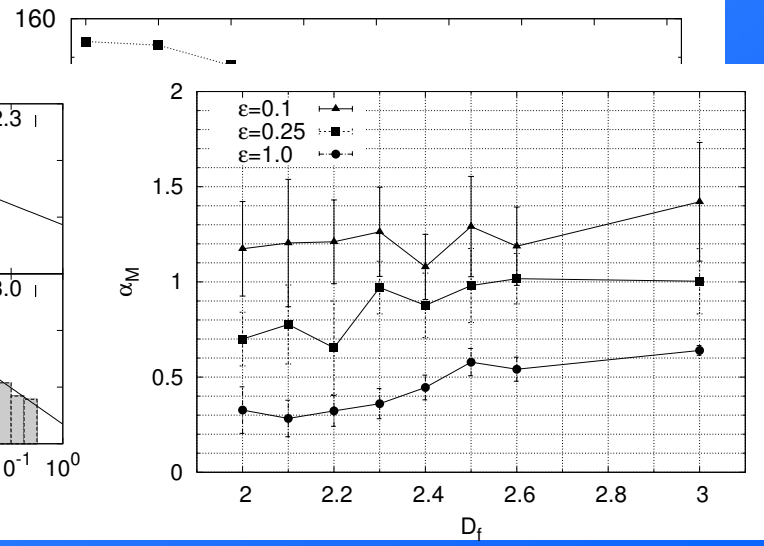
(Sanchez, Alfaro, Perez, ApJ, 2007)

Df = 2.7 +/- 0.1

Df ~ 2.6 is roughly consistent with average observed properties

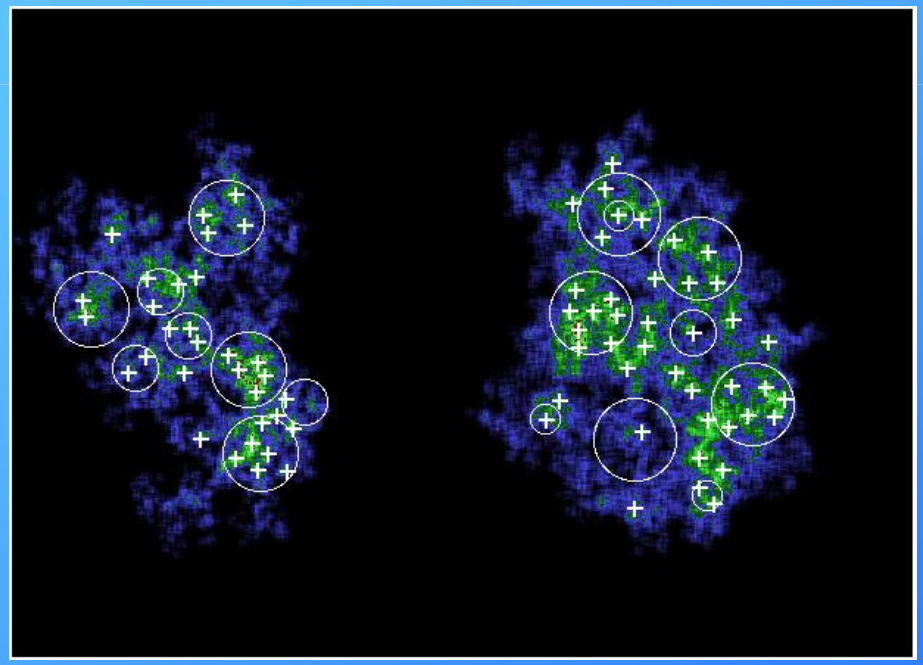
(Sanchez, Alfaro, Perez, ApJ, 2006)

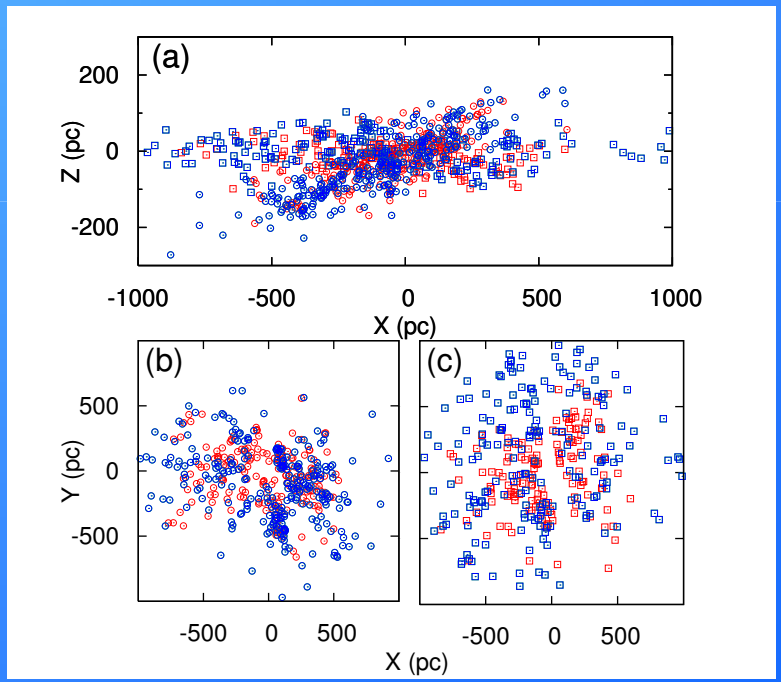




New-born stars

- Df(ISM) ---> Df (star distribution)
- Application to the Gould Belt (closest star formation complex):



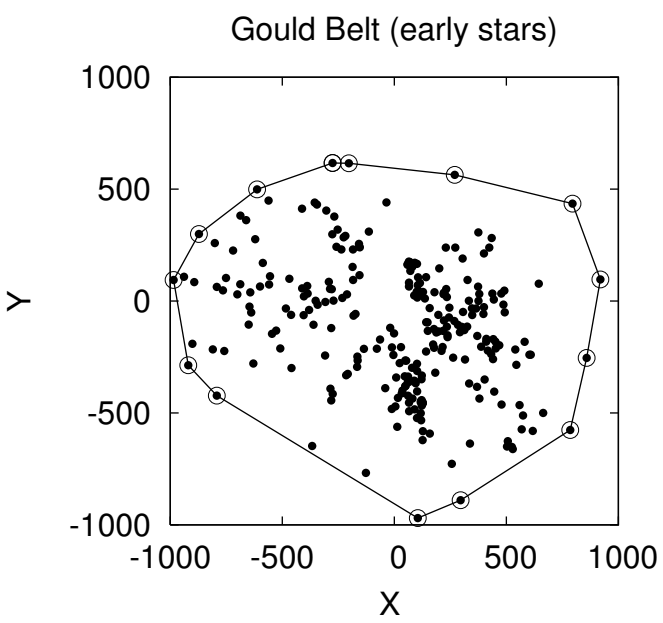


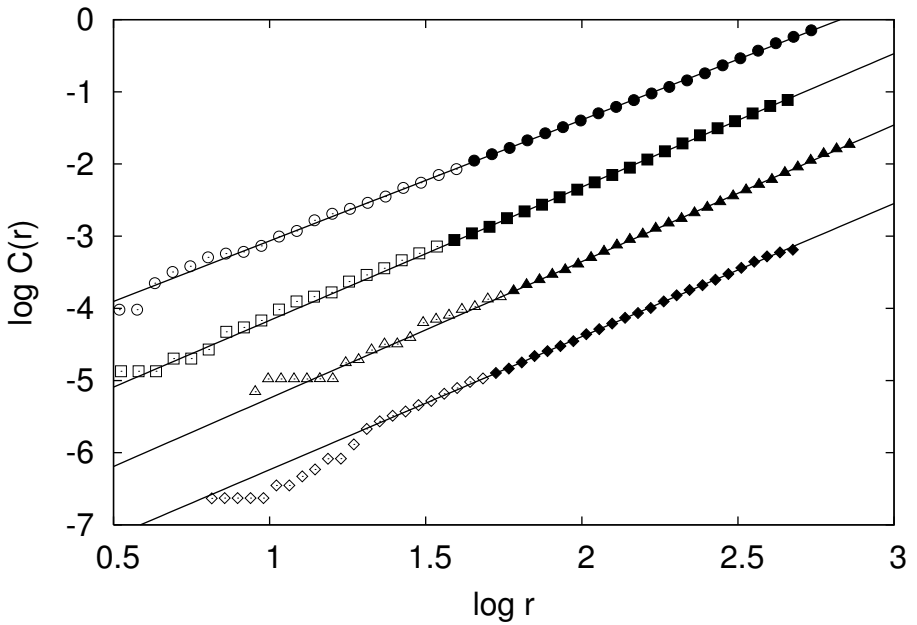
GB LGD

Blue = O-B3

Red = B4-B6

Df - Gould Belt





GB-early: Df = 2.68 +/- 0.04
GB-late: Df = 2.85 +/- 0.04
LGD-early: Df = 2.89 +/- 0.06
LGD-late: Df = 2.84 +/- 0.06

(Sanchez et al. 2007, in preparation)

Conclusions

- Well-defined fractal clouds were simulated, various Df estimators analyzed, and different effects quantified by using "good" (modesty aside) algorithms.

- Fractal analysis is a "reliable" tool for analysing *both ISM (gas) structure and star distribution*.

- Df(ISM) ≈ 2.7 +/- 0.1 (> 2.3) (universal?)
- Df GB-early = 2.68 +/- 0.04 (stars ↔ ISM?)
- Df GB-late = 2.85 +/- 0.04 (Df increase with time?)

- In the very, very near future (tomorrow?): distribution of star forming regions in galaxies, stars in clusters, etc.