“The **YSG** still **preserve** the same **structure** of the **molecular clouds** from which **they form**”

Using machine learning to reveal the fractal nature of young populations in nearby galaxies

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Introduction:

Star formation proceeds in a hierarchical way as is revealed by the presence of several length scales of the young stellar structures. They range from large stellar complexes and aggregates to small associations and clusters. The analysis of these structures shows that they exhibit self similar and fractal properties. These fractal features are also found in the structures formed by the interstellar medium (ISM), which are in turn associated with turbulence and self gravity. The study and parametrization of these properties could clarify the link between the young stellar populations and the molecular clouds in the ISM.

Data:

- HST Archive:
  ACS/WFC images.
  Photometry tables (Dalcanton et al. 2008).
- Studied galaxies:
  NGC 2403, NGC 300, NGC 253, NGC 247
  distances: ~ 2 - 3.5 Mpc.

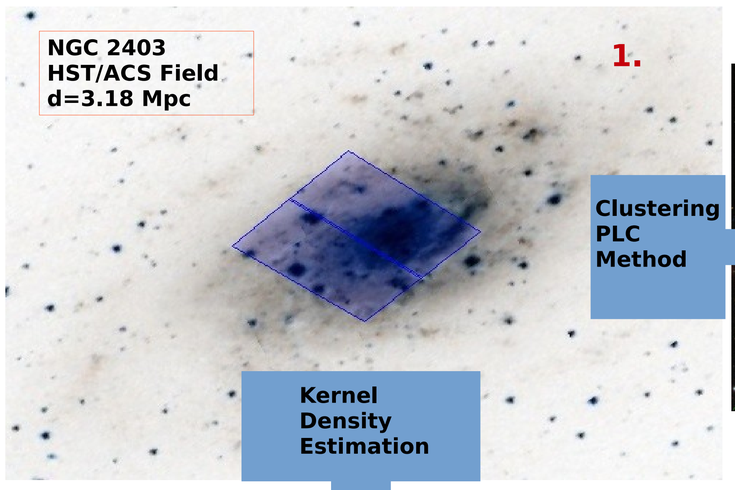
Analysis:

Analysis of the young stellar structures:

- We built the stellar density map of the upper main sequence stars, using for this the KDE method with a gaussian kernel.
- We could identified several structures over this map (Fig. 2). Most of them present inner sub structures, as is shown in the dendrogram (Fig. 3) reveling a hight degree of clustering.
- We use the perimeter (P) area (A) relation ($P \propto A^{D/2}$) , to estimate the fractal dimension (D, Mandelbrot 1982, see Fig. 4).
- We estimated fractal dimensions between 1.3 and 1.6, these values are typical for structures in the interstellar medium (ISM) and for stellar structures in the SMC and LMG.

Analysis of the young stellar groups:

- We use the PLC clustering algorithms (Batinelli 1991) to search for young stellar groups (YSG).
- We found more than 3000 YSG in the four galaxies. The Fig. 5 shows YSG found in NGC 2403.
- We built the Minimum Spanning Tree (MST) of each YSG (Fig. 6), which is the shortest possible network that connects all the stars in the cluster and there are no closed loops. With the MST we estimated the Q parameter.
- We use the Q parameter to determinate if the distribution of stars in a YSG follow a fractal distribution (Q <0.8) or a central concentration of stars with a radial gradient (Q > 0.8).



Conclusions:

- For most of the structures in the density map a high degree of clustering is revealed by the dendrograms.
- We obtained fractal dimensions similar to those obtained in other star-forming regions and the ISM. They are consistent with a scenario of hierarchical star formation regulated by supersonic turbulence and self gravity.
- We detected thousands of YSG by means of the PLC method
- The internal structure of almost all the YSG presents a fractal distribution. This fact suggests that the studied populations are very young and the groups still preserve the same structure of the molecular clouds from which they form.

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