The Green Bank Ammonia Survey (GAS): Investigation of the Hierarchical Structures of Nearby Star-Forming Regions

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Question: Can we use dendrograms to characterize the **hierarchical structures** of multiple star-forming regions (SFRs) simultaneously? By doing so, we can identify stellar core candidates and characterize the filaments in which they form.

Our Data:

- Green Bank Ammonia Survey (GAS)
- Large scale survey conducted with Green Bank Telescope to map nearby SFRs in Gould Belt (d < 500pc)
- 1cm wavelength ammonia transitions
- Resolution: 5.7 kHz @ 23.7 GHz
- Data Release 1 (Friesen et al. 2017)

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Dendrograms: The Basics

- Tree-like diagrams that divide data into structures
- Python's *astrodendro* package has 3 key parameters
  - *min_value*: Minimum flux value to be considered "real"
  - *min_delta*: Minimum flux difference for neighboring structure to be independent
  - *min_npix*: Minimum number of pixels for structure to be independent

Sample Structure Decomposition

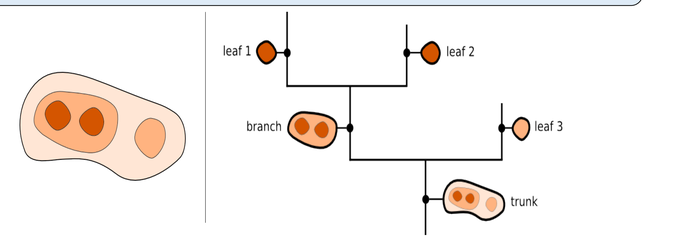


Figure 1. Sample molecular cloud structure **(left)** Decomposition of sample structure into dendrogram with trunk, branch, and three leaves **(right)**

Example Structure Decomposition

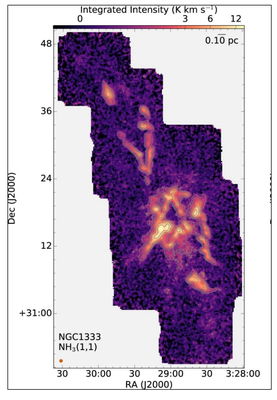


Figure 2. **Integrated intensity** (0th moment) map of **NGC1333** from GAS. Mapped with the ammonia (1,1) transition. Brighter parts represent denser regions.

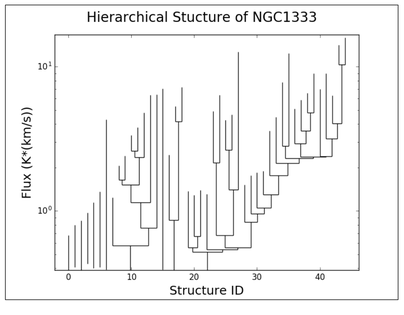


Figure 3. **Dendrogram of NGC1333**. **Structure intensity**, in Kelvin km s^{-1}, is plotted on the y-axis. The **ID number** of each structure is plotted on the x-axis. Densest, smallest components of region shown as upper-level structures (leaves). Diffuse, large components depicted as lower-level structures (trunks).

Identifying Optimal Parameters:

- Vary one parameter while controlling other
  - Search for trends in relevant statistics as parameters change

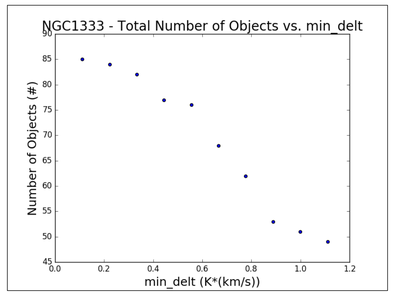
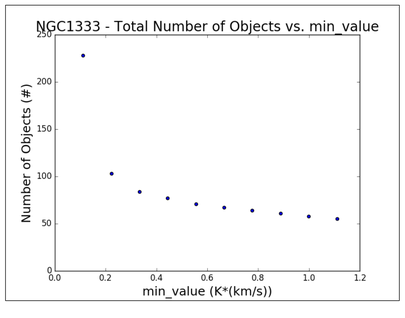


Figure 4. Plot of **total objects** detected by dendrogram for NGC1333 (y-axis) for varying **min_delta** value (x-axis). Each data point represents unique multiples of the median rms. As this parameter is increased, the dendrogram detects less total objects. This trend is valuable in identifying an ideal parameter value.

Figure 5. Plot **of total objects** detected in NGC1333 by dendrogram (y-axis) for varying **min_value** (x-axis). Each data point represents unique multiples of the median rms. The min_value parameter is inversely proportional to the total number of objects generated by the dendrogram.



What Did We Find?:

- Smaller structures did not tend to be round
  - → Not gravitationally bound?
- "Leaves" had no preferred orientation
  - → Not influenced by larger-scales?

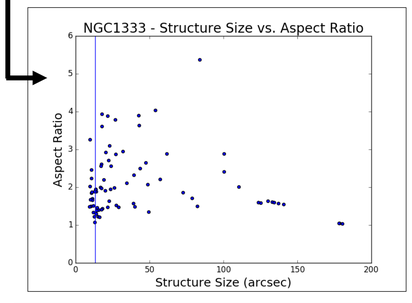
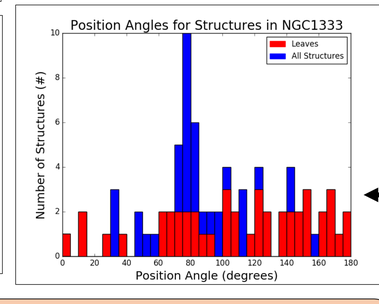


Figure 6. Plot of **aspect ratio** (ratio of sizes of major and minor axes) for all objects detected by dendrogram vs. **structure size** (radius). No distinct correlation between structure size and aspect ratio.

Figure 7. **Histogram of position angles** for all structures (blue) and leaves (red). Number of objects at particular angle is plotted on y-axis. The specific position angles are plotted on the x-axis. No obvious relationship between alignment of leaves and all other structures.



What's Next?: This project demonstrated the utility of dendrograms in characterizing the hierarchical structures of nearby star-forming regions and offering preliminary physical analyses of identified structures. We plan to **utilize a variety of hierarchical structure algorithms**, including dendrograms, to conduct **virial analyses** on regions of interest to compare how measured physical parameters vary for different approaches.

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