SUBCLUSTERS OF YOUNG STARS IN MASSIVE STAR FORMING REGIONS

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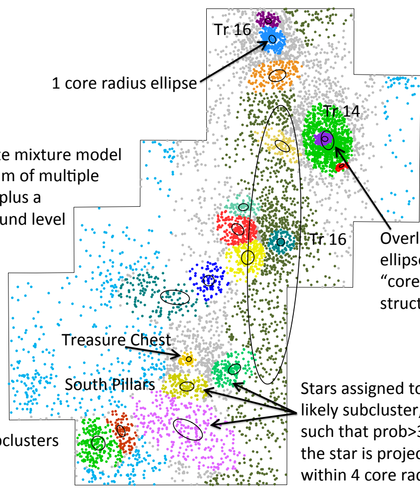
MYStIX

Massive Young Star-Forming Complex Study in Infrared and X-ray (Feigelson et al. 2013): improved censuses of young stars in 20 nearby OB-dominated star-forming regions that were observed by the Chandra X-ray observatory, the Spitzer Space Telescope, and the UKIRT/UKIDSS and 2MASS surveys. The sample of >33,000 members reveals new details about the structure of clusters in these regions. http://www.astro.psu.edu/mystix

Identification of Subclusters

Model of surface density — Subclusters are assumed to have the structure of "isothermal" ellipsoids, i.e. a nearly flat core with power law wings. In statistical parlance, the collection of subcluster models is a **finite mixture model**.

The Greater Carina Nebula



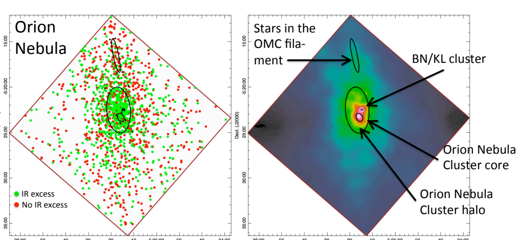
Statistically find the number of clusters by **numerical optimization** of a penalized likelihood (Akaike Information Criterion; **AIC**)

$$\log L(\theta;\mathbf{x}) = \sum_{i=1}^{n} \log \Sigma_\theta(x_i) - \int_{W} \Sigma_\theta(u)\mathrm{d}u,$$

$$AIC = -2L + 2(6k+1),$$

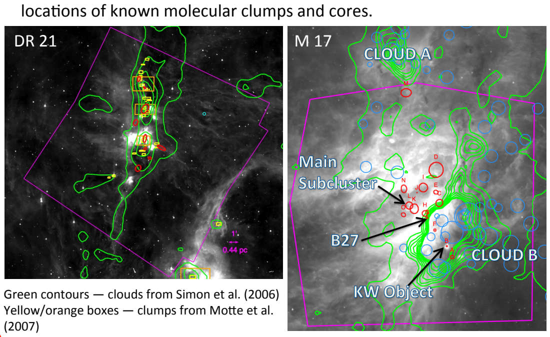
Cluster Structures

A variety of structures can be identified using finite mixture models. For example, a layered structure can be identified in Orion.



(Orion sample obtained from Megeath et al. (2012) and Getman et al. (2005))

Star clusters (red) plotted on 8μm *Spitzer* images correspond to the locations of known molecular clumps and cores.

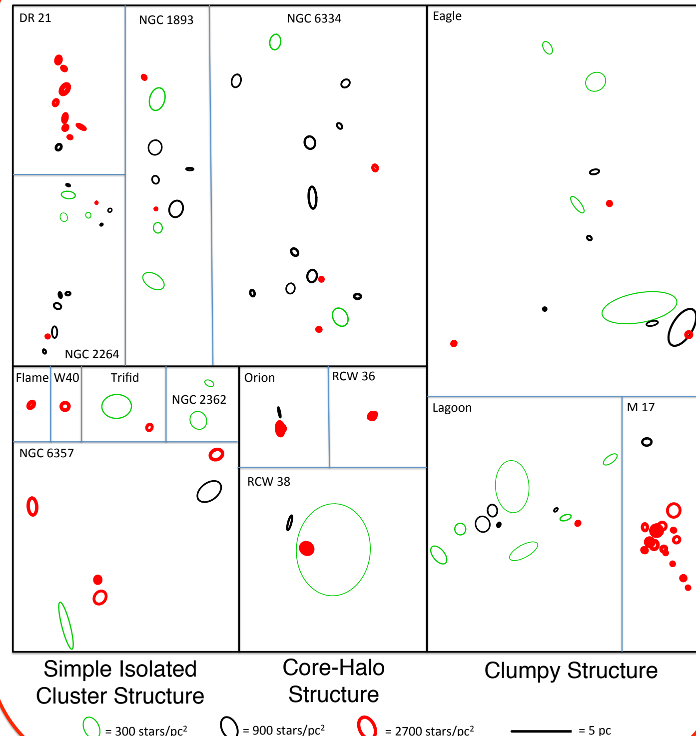


Green contours — clouds from Simon et al. (2006)
Yellow/orange boxes — clumps from Motte et al. (2007)

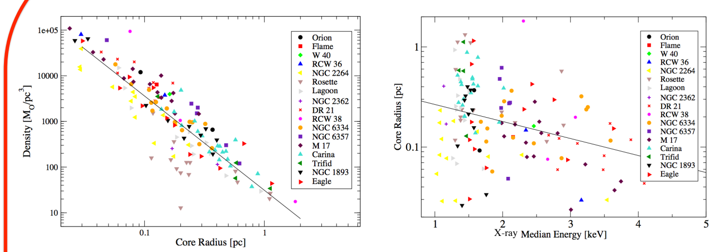
Green contours — clouds from Povich et al. (2009)
Blue circles— cores from Wilson et al. (2003)

Structural Classifications

Filamentary Cluster Structure

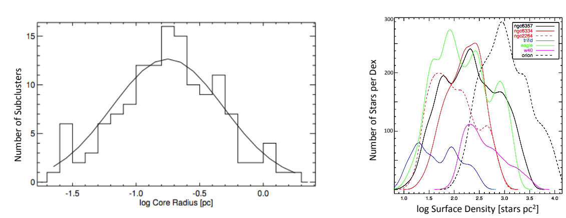


Signs of Cluster Expansion



(Left) There is a power-law relation between the fitted cluster central density and core radius (index slightly shallower than -3). This effect is similar to the trend identified by (2009), which was explained as cluster expansion with age. ***(Right)*** There is a statistically significant inverse relationship between core radius and X-ray median energy (objects with higher X-ray median energy are more highly absorbed). Absorption can be treated as a proxy for age (see poster by Getman et al.), so this effect is also evidence of expanding subclusters.

Typical Cluster Structure Properties



(Left) The distribution of cluster core radii is roughly log-normal, peaked at 0.18 pc (similar to the ONC) with a standard deviation of 0.4 dex. ***(Right)*** Typical surface densities in these star-forming regions range from 30 to 1500 stars/pc². Our results show no special value of surface density common to all the regions, which does not agree with the conclusion from Bressert et al. (2010) in their study of nearby young stellar objects.