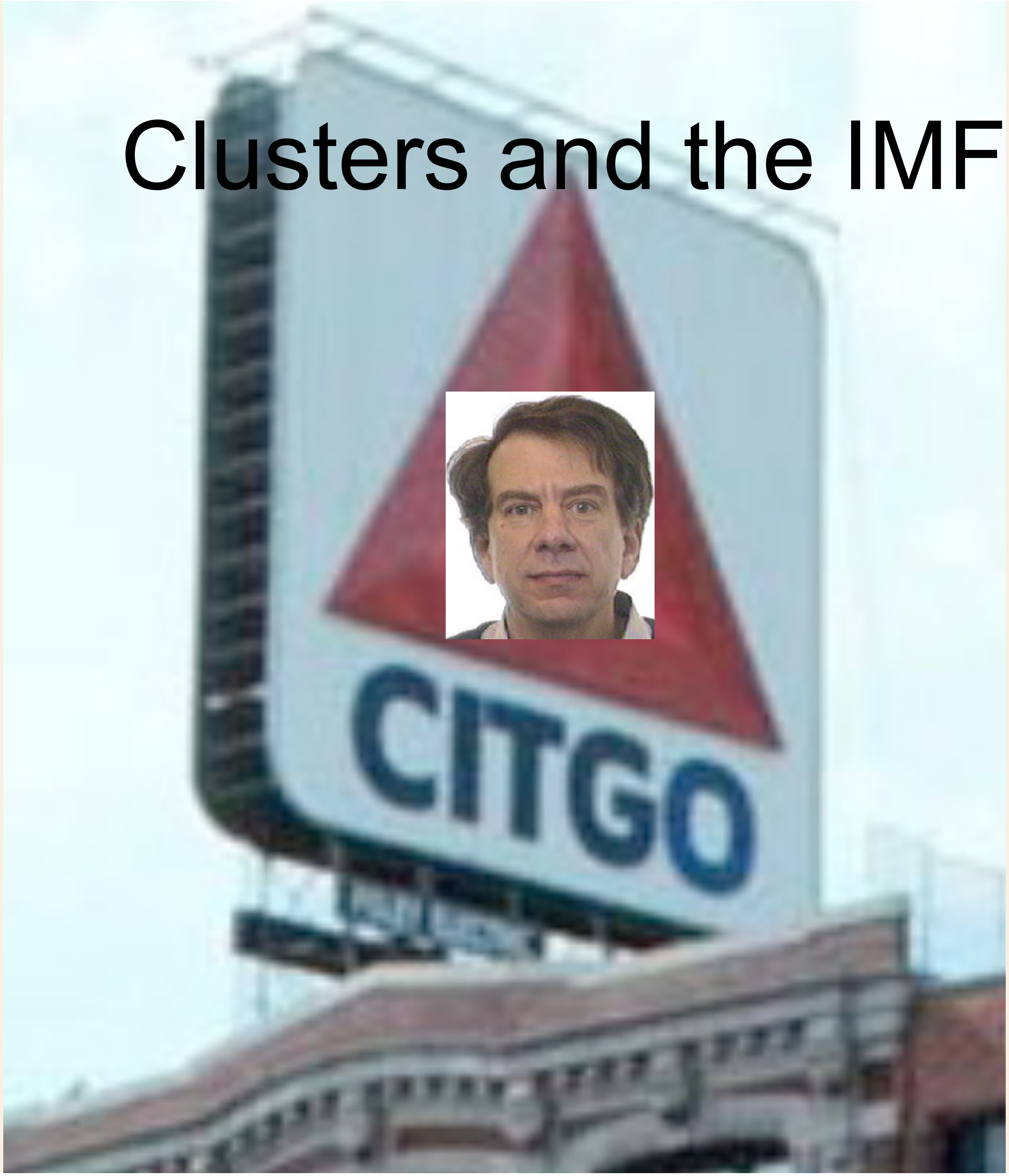
Clusters and the IMF



Clusters and the IMF

1:20 Pre-Spitzer (clusters Y2K) - Allen

1:35 Cluster / Cloud Structure - Gutermuth

2:00 Phil-amentary star formation in L1641- Megeath

2:15 Membership of Taurus cloud, recent progress on the stellar IMF, musings on cluster ages - Hillenbrand

2:30 Discussion - All

Clusters Y2K

- 1970s and 1980s : painstaking raster scans revealed embedded sources and clusters.
- 1980s and 1990s : Myers and collaborators (many students and postdocs) determined the physical properties of low-mass cores *and* their stellar content, relating the two.
- 1990s and 2000s : these studies were extended to the cluster scales, then cloud scales, and now Galactic spiral-arm scales.

Early imaging of embedded clusters

A 2-MICRON MAP OF THE OPHIUCHUS DARK-CLOUD REGION

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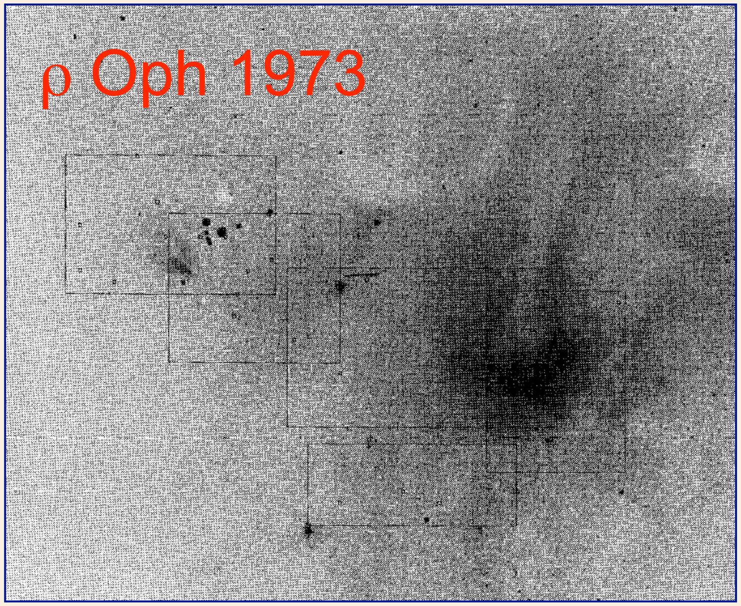
Received 1973 May 21; revised 1973 June 4



the mapped region. We must conclude that the sources listed in table 1 constitute a much more compact clustering than is typical for the OB association. Even more interesting is the comparison of stellar densities within the cloud with other clusters. The diameter of the region mapped is approximately 1 pc. However, the depth of the region along the line of sight is unknown. If we assume a depth of 3 pc as suggested by the approximate cloud extent of 1°, then our sample volume is ~2.2 pc^3. The stellar density is then ~20 pc^{-3} for stars brighter than $M_V = +2$. The corresponding numbers for the Pleiades and h Persei are respectively 6 and 7 pc^{-3}. By extrapolating the observed luminosity function for M67 (Sandage 1957) using the Salpeter initial luminosity function, we estimate a density of 15–20 stars pc^{-3} brighter than $M_V = +2$ for the central region of this old, rich open cluster. Although we have probably detected only the B and A stars, their observed density suggests that we are observing a rich open cluster located in the center of the Ophiuchus clouds. If we take the expansive view that all sources except source 1 have large intrinsic infrared excesses, then we are observing an extraordinary cluster of newly born stars.

What was Phil doing (in`73)?

1	1971MEQPR.102...21M	1.000 00/1971		U
	Myers, P. C.; Barrett, A. H.	Formaldehyde absorption in three dark galactic clouds.		
2	1972PhDT........29M	1.000 00/1972	C	U
	Myers, Philip Cherdak	Microwave Observations of Molecular Spectral Lines in Galactic Clouds.		
3	1972ApJ...176..111M	1.000 08/1972 A	F G	R C U
	Myers, P. C.; Barrett, A. H.	An Attempt to Detect the 3-CENTIMETER Fine-Structure Transition of Hydrogen in H II Regions		
4	1972ApJ...178L..23B	1.000 11/1972 A	F G	R C S U
	Barrett, A. H.; Martin, R. N.; Myers, P. C.; Schwartz, P. R.	Observations of Methanol in Sagittarius b2 at 48 GHz		
5	1973QB1.A88n229v26.	1.000 00/1973		C K U
	Myers, Philip Cherak	Observations of OH and H2CO toward galactic dust clouds		
6	1973ApJS...26...83M	1.000 08/1973 A	F G	R C U
	Myers, P. C.	Observations of OH and H_{2}CO Toward Galactic Dust Clouds		
7	1974BAAS....6..263M	1.000 03/1974	F G	U
	Myers, P. C.	Study of correlations among OH, H_2O, H I and dust toward W44.		
8	1974BAAS....6Q.436M	1.000 09/1974	F G	
	Myers, P. C.	A Search for Continuum Radiation from Dust Clouds.		
9	1975ApJ...198..331M	1.000 06/1975 A	F G	R C S U
	Myers, P. C.	Molecule-dust correlations in dark cloud Khavtassi 3		
10	1975ApJ...202L..25M	1.000 11/1975 A	F G	R C S U
	Myers, P. C.; Ho, P. T. P.	Formaldehyde in the rho Ophiuchi dark cloud		
11	1976BAAS....8..335M	1.000 03/1976	F G	C U
	Myers, P. C.; Ho, P. T. P.; Schneps, M. H.; Chin, G.; Pankonin, V.	Spatial Extents and Gas Motions in the Rho Ophiuchi Dark Cloud		
12	1976BAAS....8Q.350B	1.000 03/1976	F G	U
	Barrett, A. H.; Ho, P. T. P.; Myers, P. C.	Ammonia in the Kleinmann-Low Nebula		
13	1976BAAS....8R.514H	1.000 09/1976	F G	U
	Ho, P. T. P.; Myers, P. C.; Barrett, A. H.	An Upper Limit on the Kinetic Temperature, Turbulence, and Collapse Velocity in the Taurus Dust Cloud.		
14	1977ApJ...211L..39B	1.000 01/1977 A	F G	R C U
	Barrett, A. H.; Ho, P. T. P.; Myers, P. C.	Ammonia in the Kleinmann-Low nebula		
15	1977ApJ...211..737M	1.000 02/1977	F G	R C S U

More and more molecules!

ρ Oph cluster 10 years later…

THE DISCOVERY OF NEW EMBEDDED SOURCES IN THE CENTRALLY CONDENSED CORE OF THE RHO OPHIUCHI DARK CLOUD: THE FORMATION OF A BOUND CLUSTER?

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Received 1982 August 2; accepted 1983 April 22

1983

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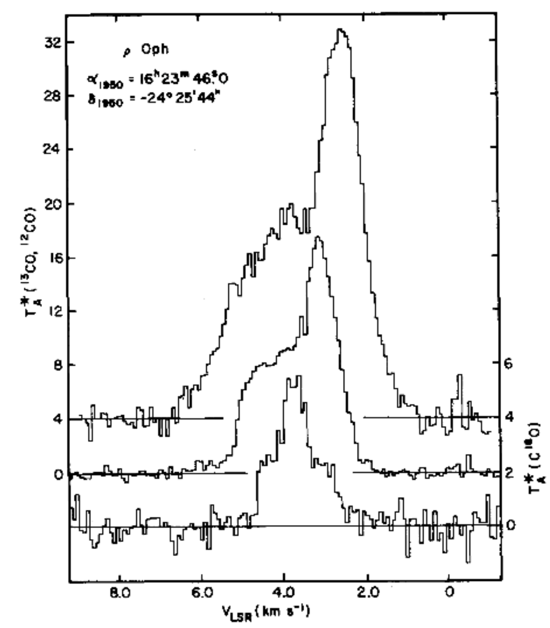

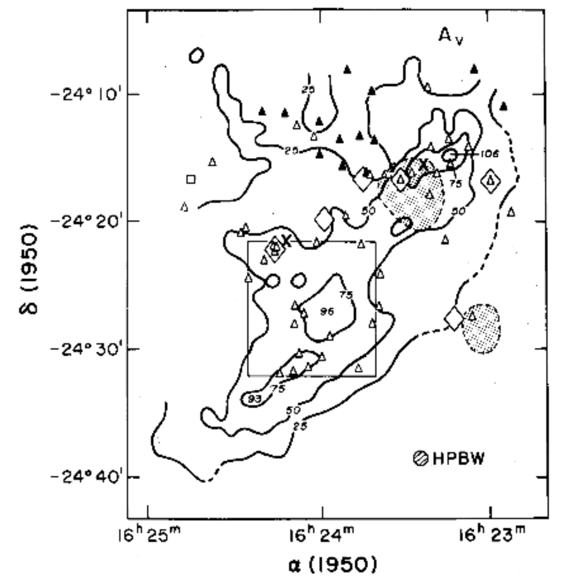

SEDs of IRAS Sources

and their correspondence with dense cores

THE ASTROPHYSICAL JOURNAL, **319**:340–357, 1987 August 1

IRAS

NEAR-INFRARED AND OPTICAL OBSERVATIONS OF *IRAS* SOURCES IN AND NEAR DENSE CORES

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Received 1986 June 16; accepted 1987 January 23

SEDs of IRAS Sources

and their correspondence with dense cores

1987ApJ...319..34

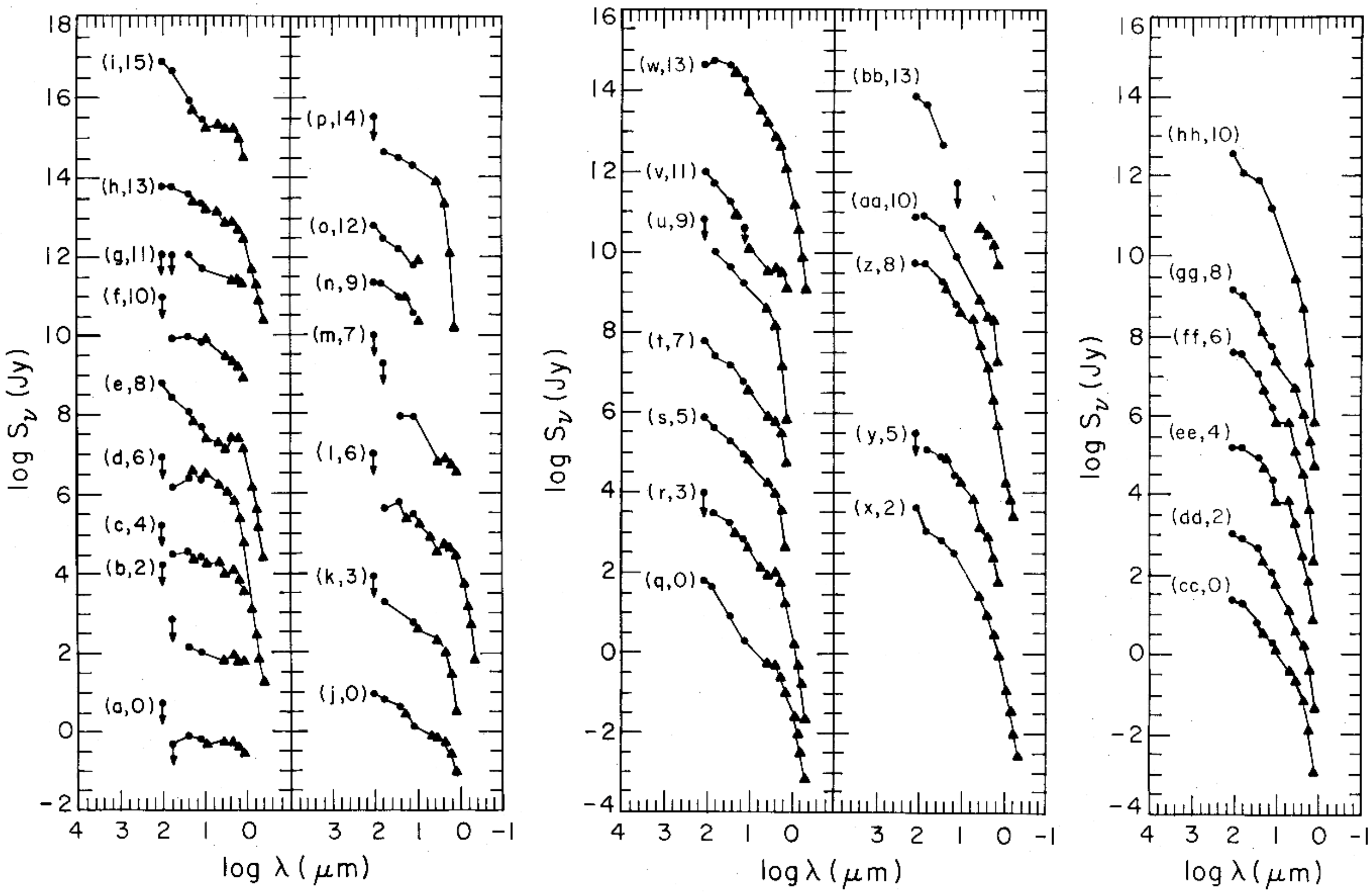
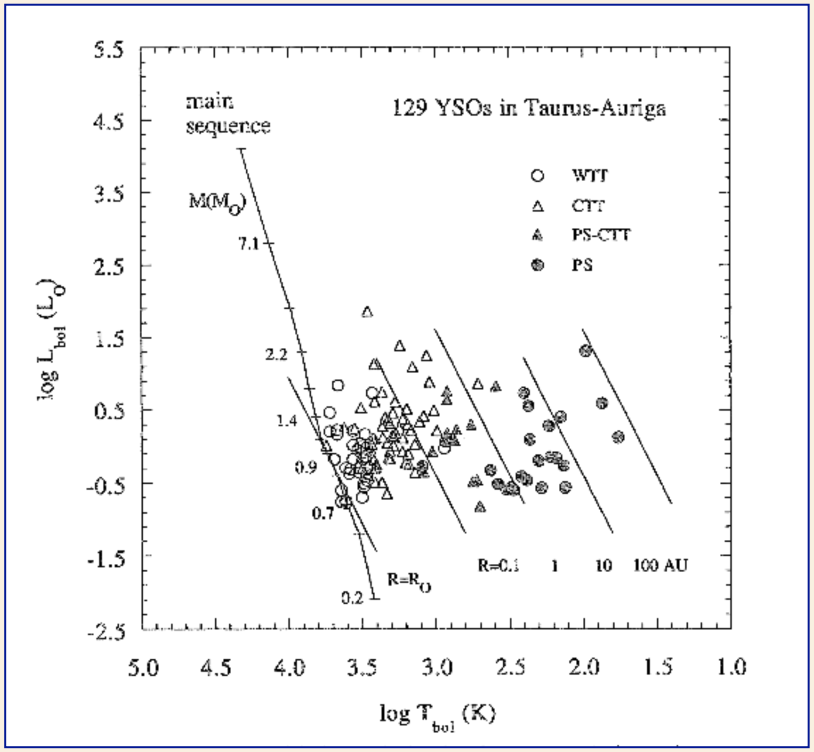


FIG. 1.—Log-log flux density spectra from 0.4 to 100 μm of *IRAS* sources in Table 3, arranged in order of increasing spectral slope *s*. The ordinate contains an integer offset, which differs from source to source to facilitate presentation. In parentheses at the left of each spectrum is the offset value, and a letter code for the source name, listed in Table 3A. *Circles: IRAS* data; *triangles*: data presented in this paper. Symbols with downward-pointing arrows are 3 σ upper limits. Flux density uncertainty is generally smaller than or comparable to the size of the plotting symbol.

Evolution and Spatial distribution of YSO in Taurus-Auriga



BOLOMETRIC TEMPERATURES OF YOUNG STELLAR OBJECTS

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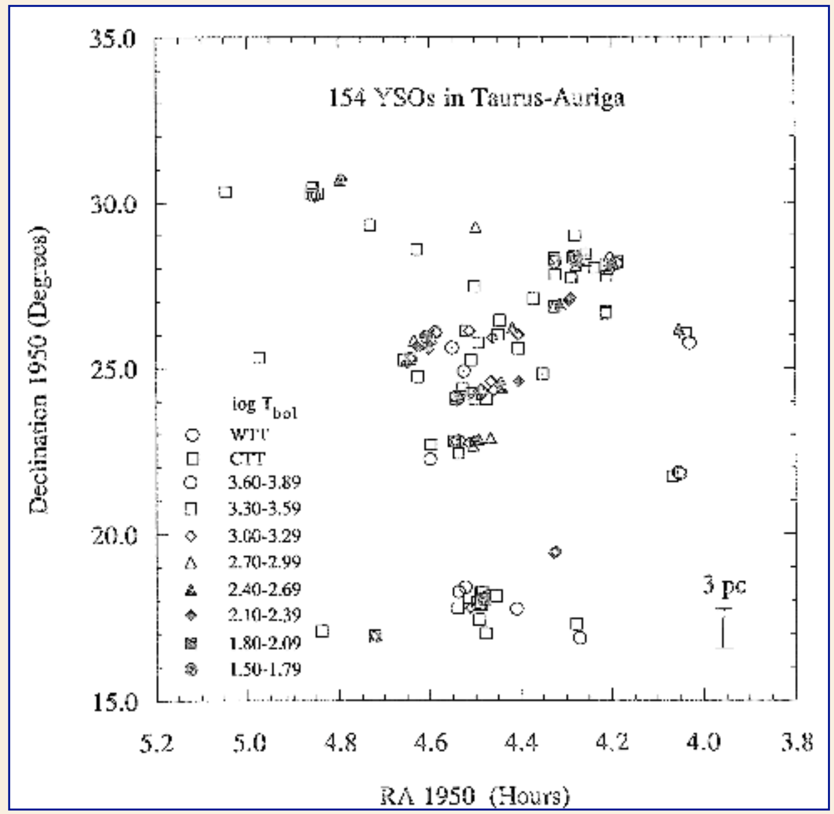
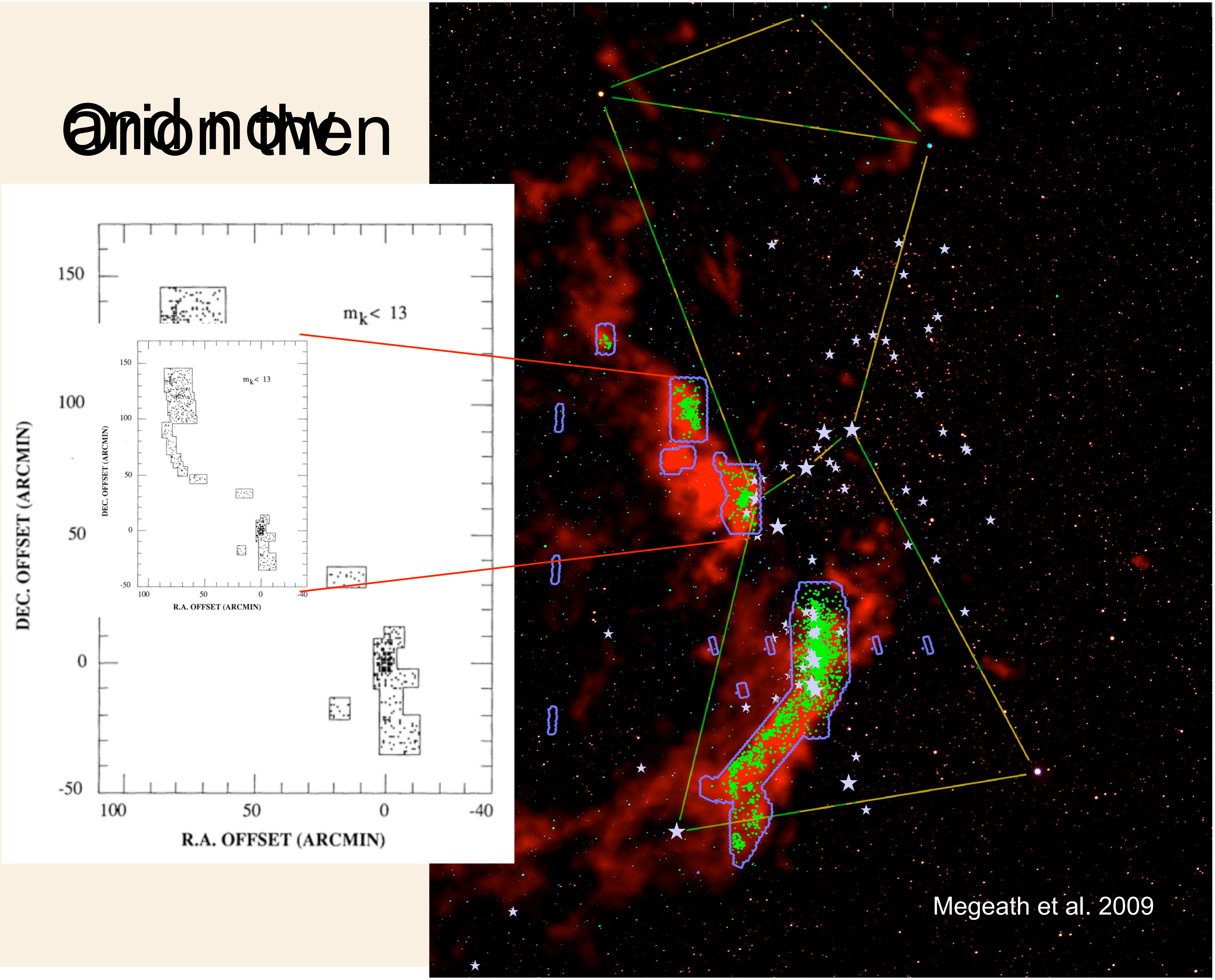
1993



Orion then
and now



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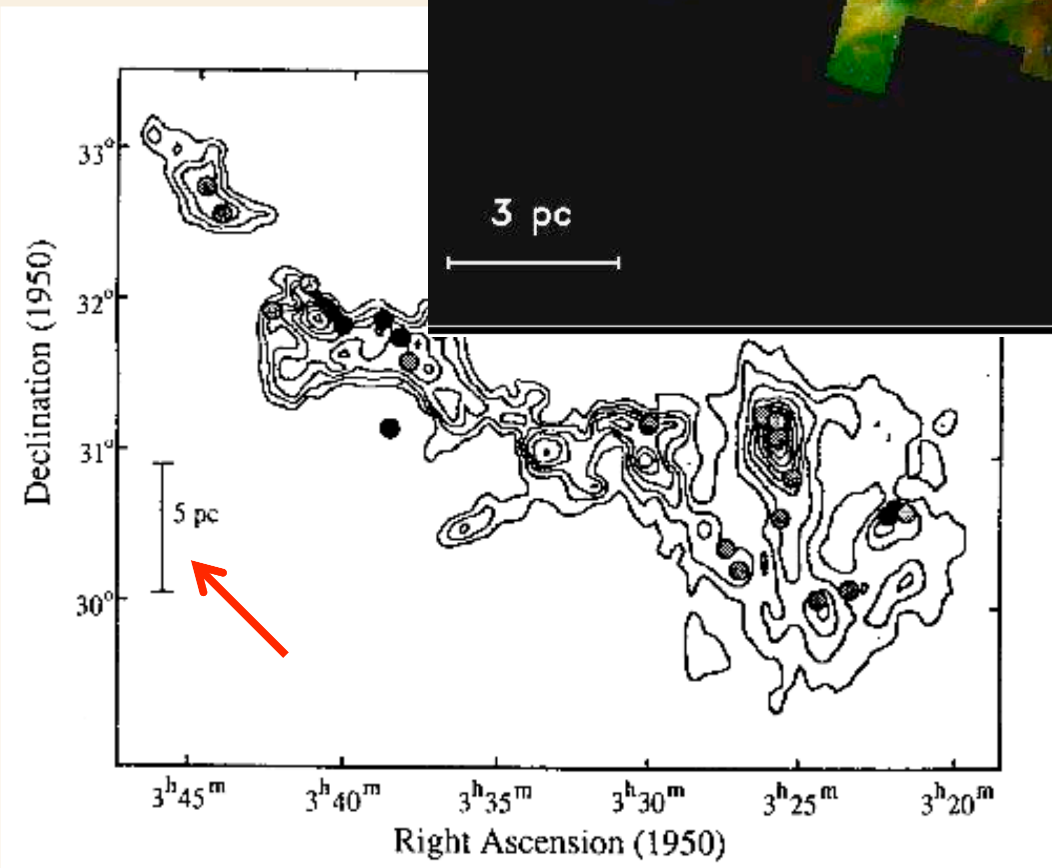

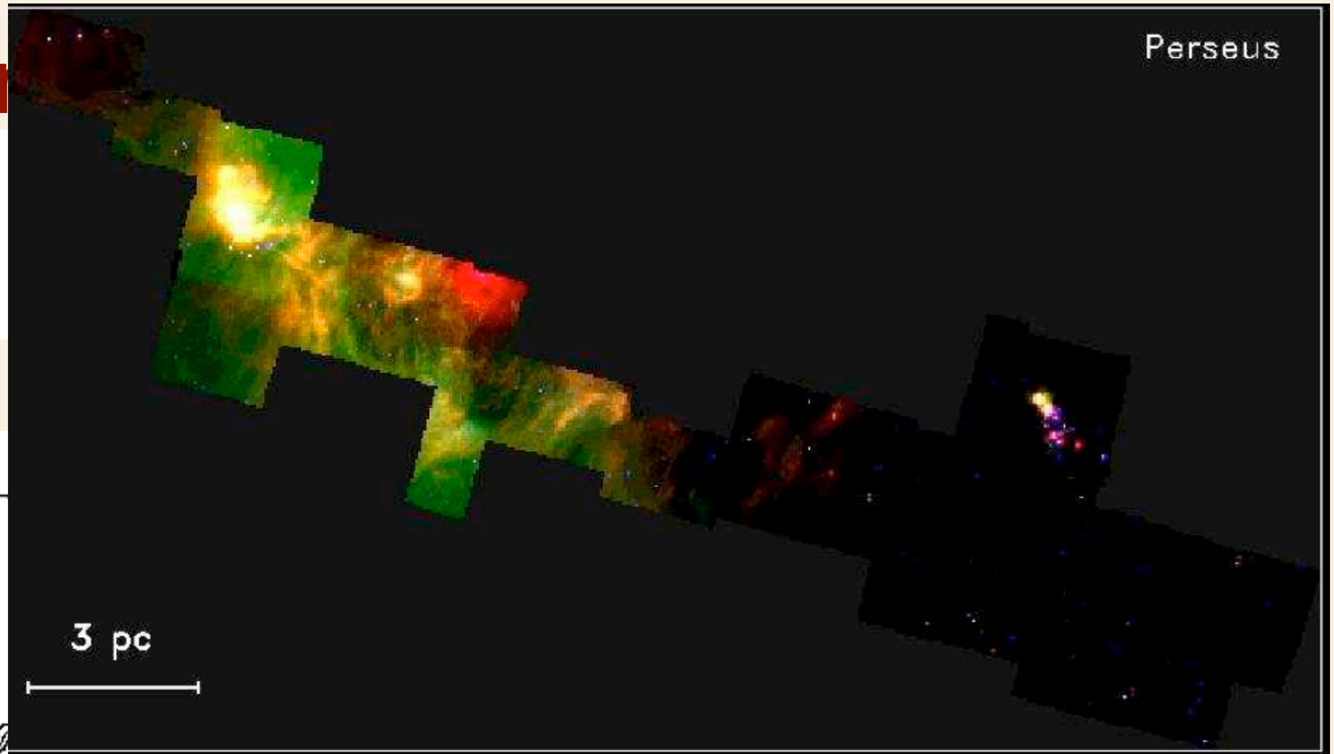

Evolution of young clusters

BOLOMETRIC TEMPERATURE AND YOUNG STARS IN THE TAURUS AND OPHIUCHUS COMPLEXES

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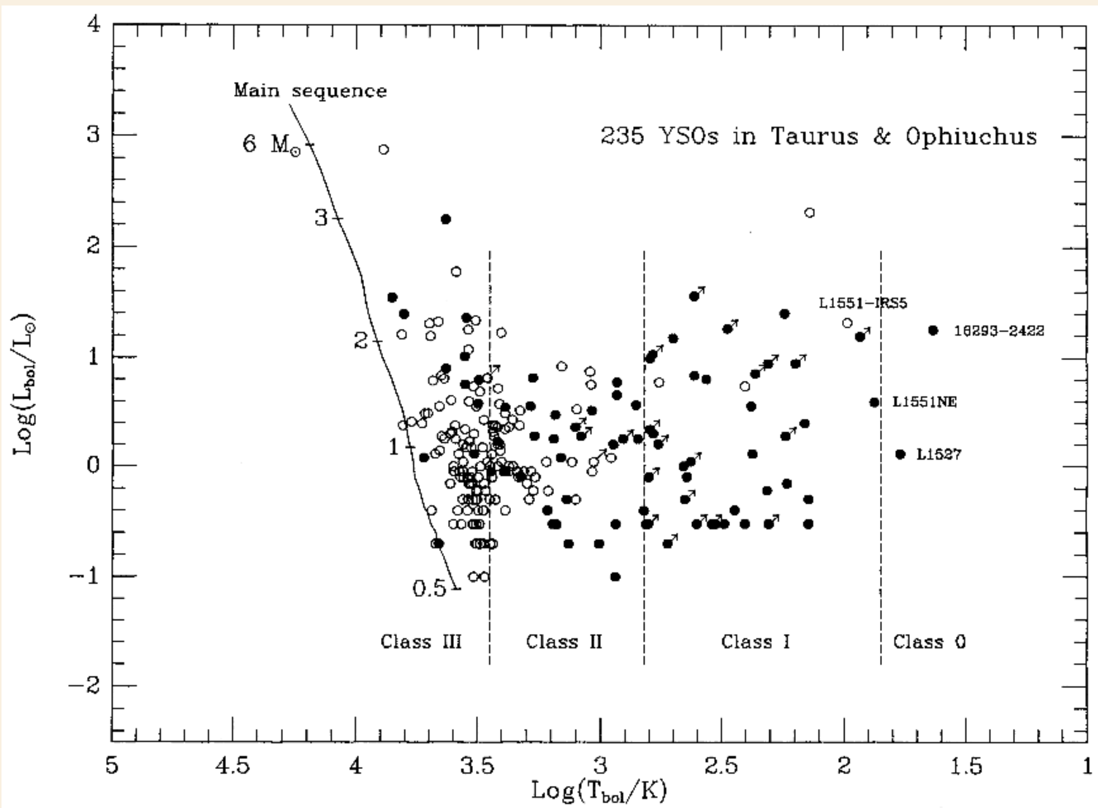
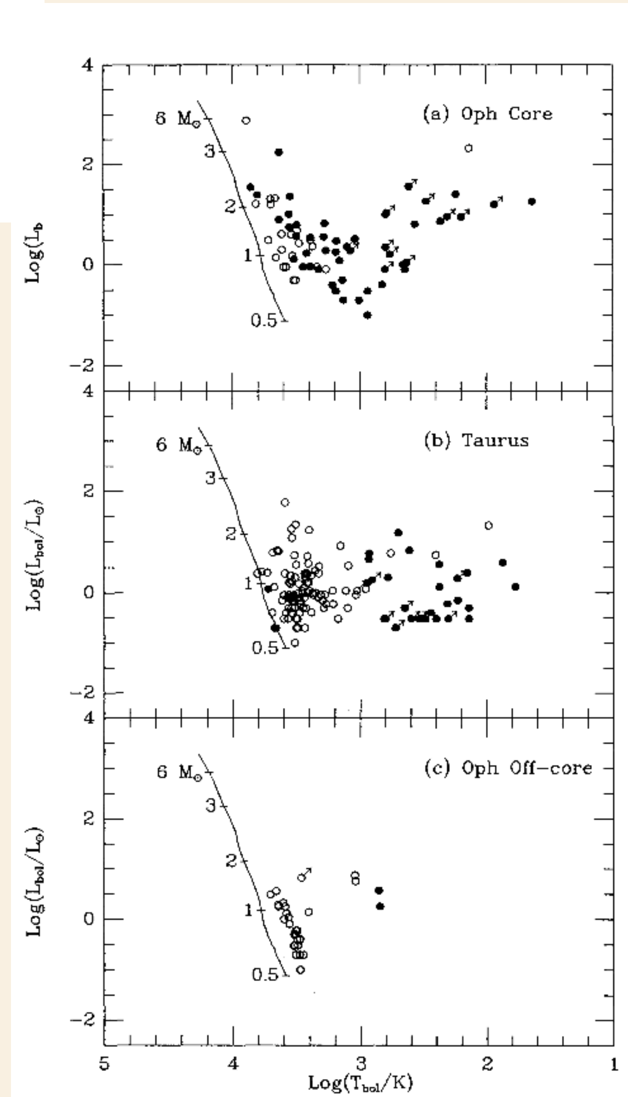
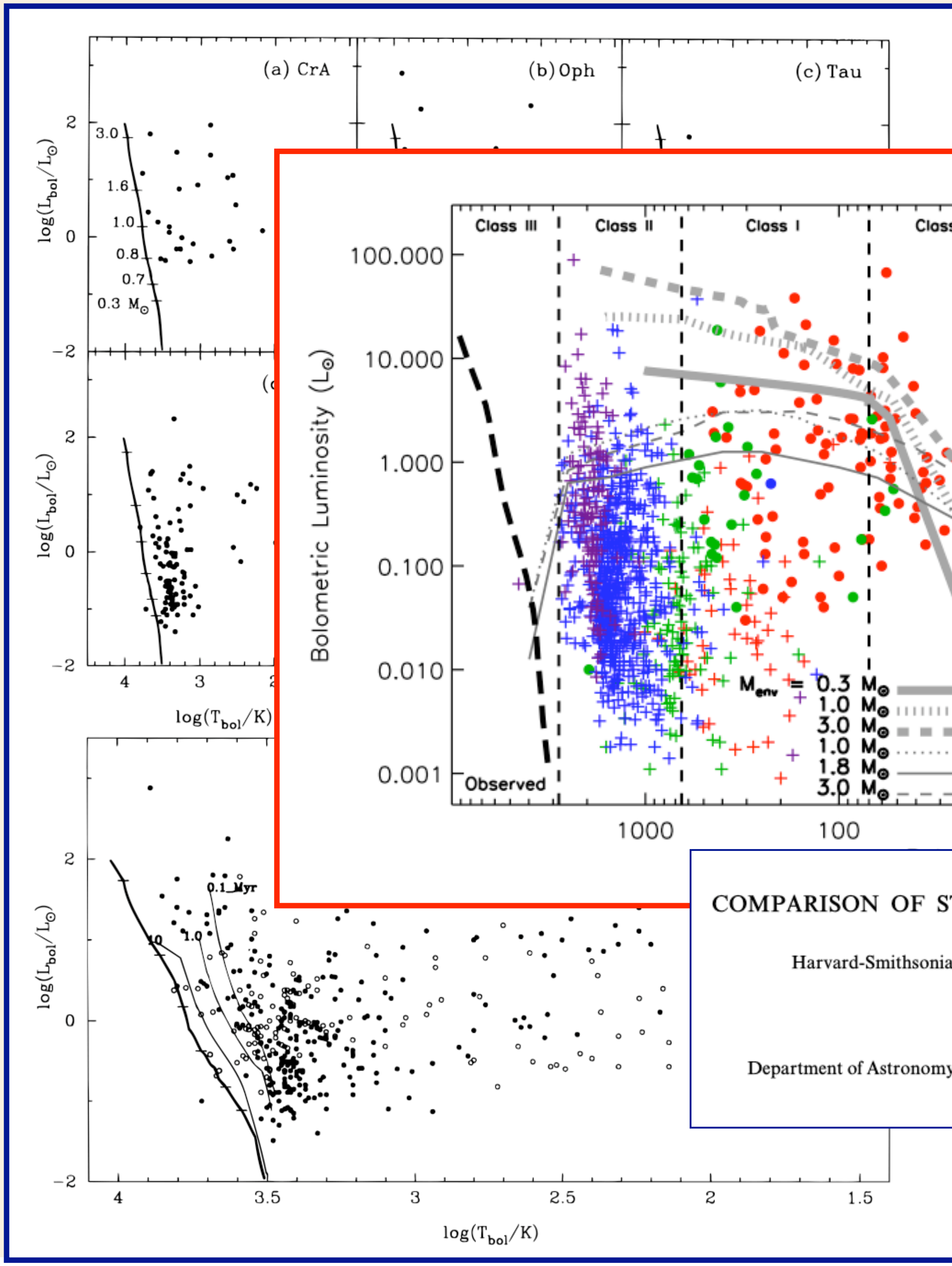
The Astrophysical Journal, 445:377–392, 1995 May 20

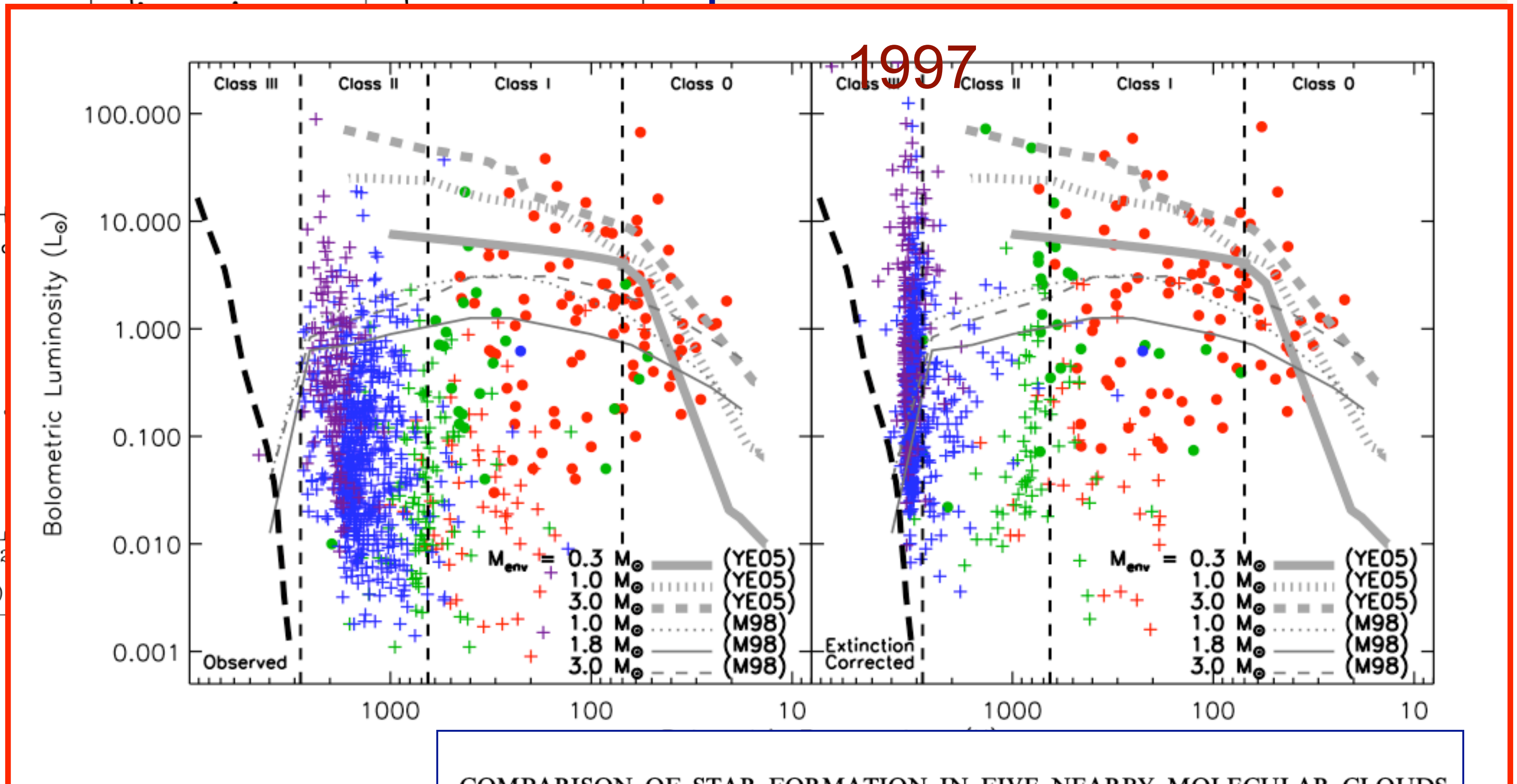




Comparison of clusters

1997





COMPARISON OF STAR FORMATION IN FIVE NEARBY MOLECULAR CLOUDS

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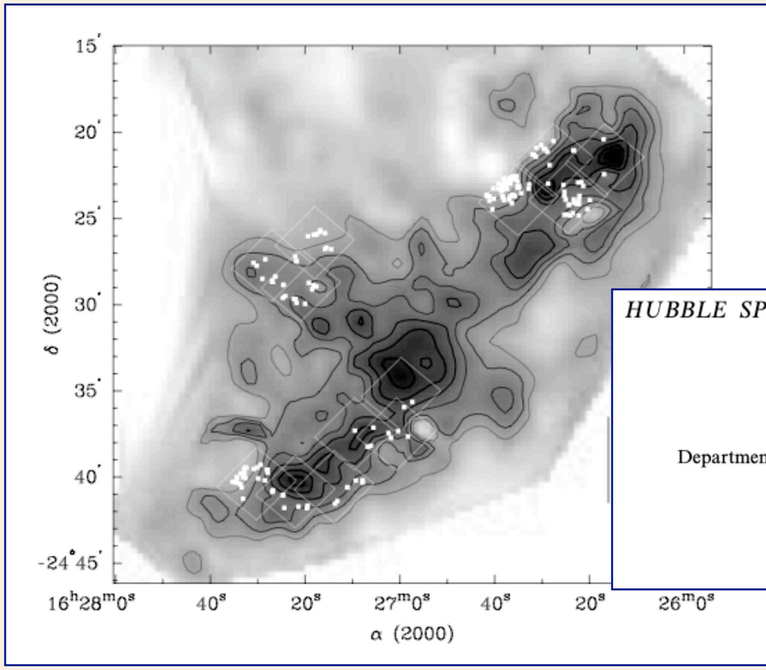
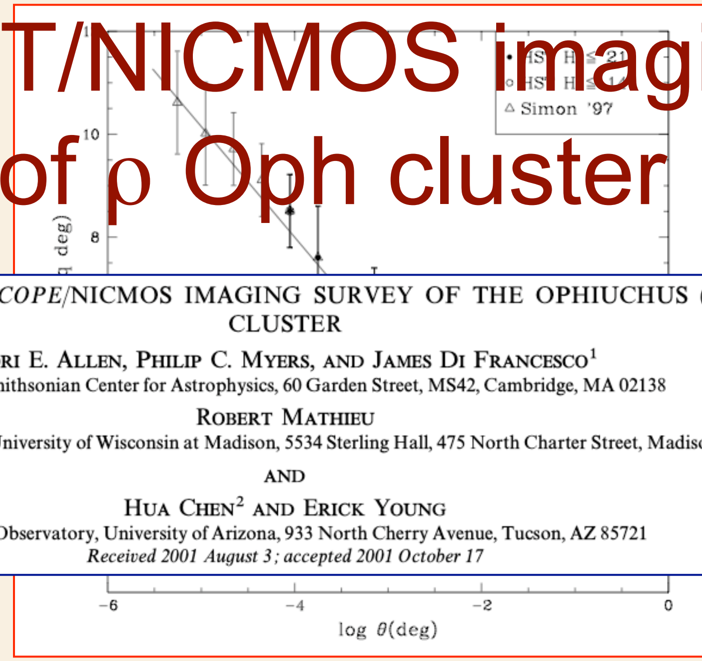
HST/NICMOS imaging of ρ Oph cluster





HUBBLE SPACE TELESCOPE/NICMOS IMAGING SURVEY OF THE OPHIUCHUS (LYNDS 1688) CLUSTER

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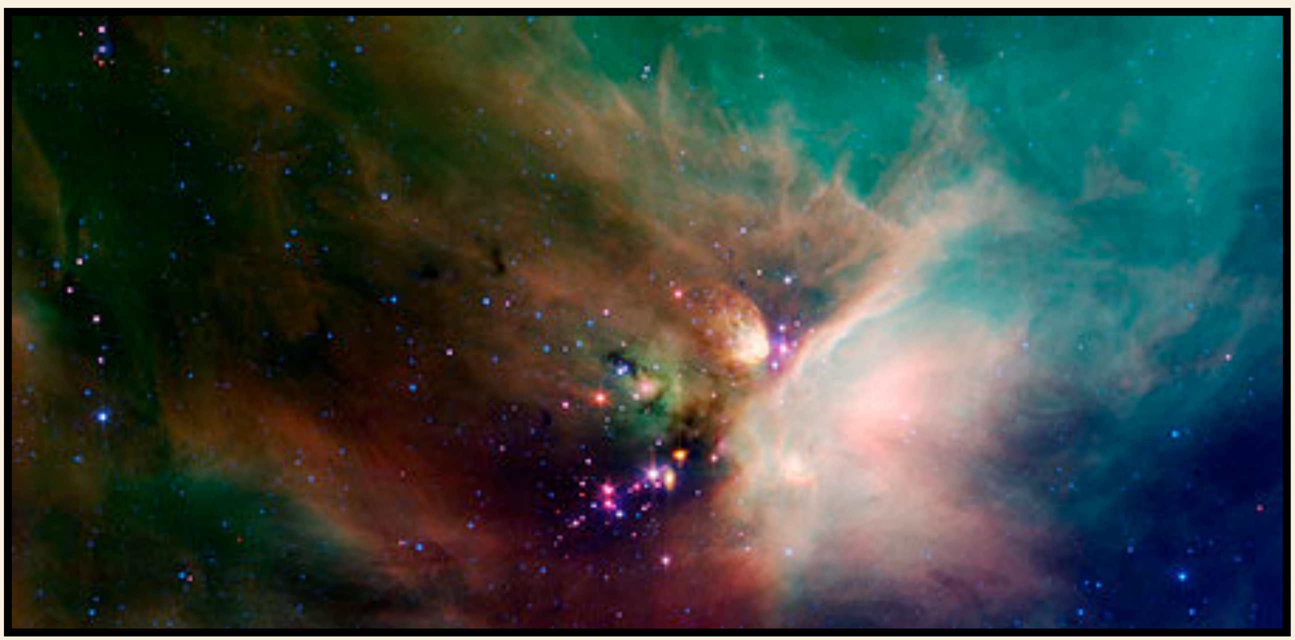

Young Stellar Clusters w/in 1 kpc

A CATALOG OF YOUNG STELLAR GROUPS AND CLUSTERS WITHIN 1 KILOPARSEC OF THE SUN

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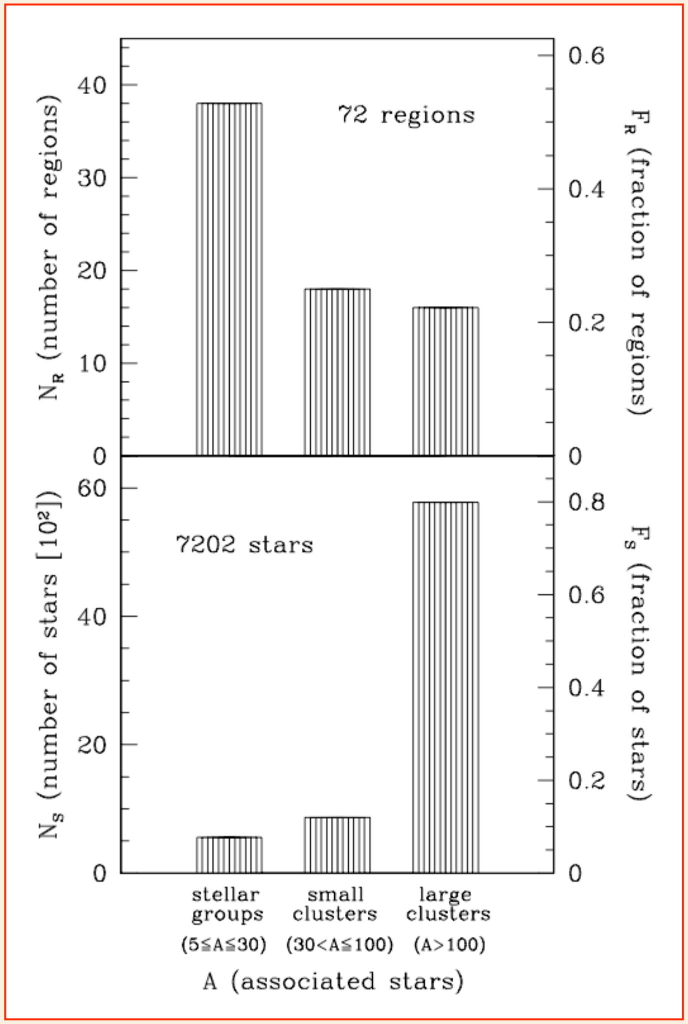
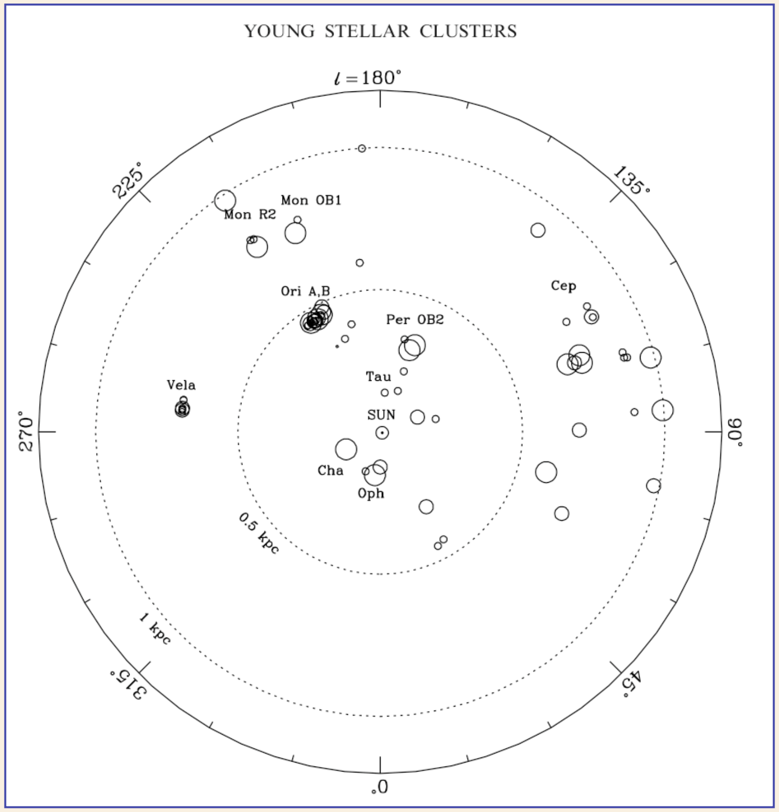
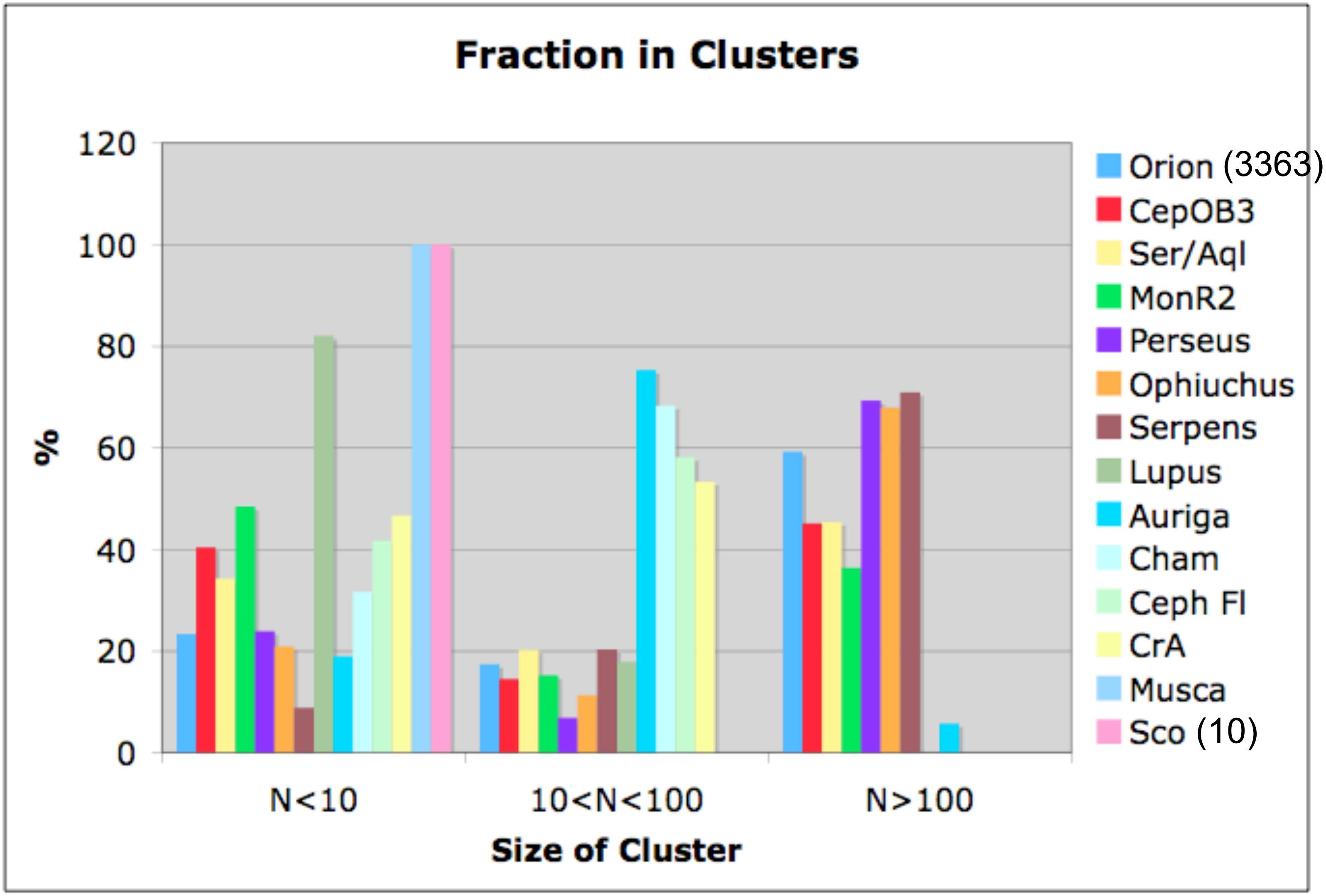
The Astronomical Journal, 126:1916–1924, 2003 October





For 14 cloud complexes within 1 kpc, the fraction of young stars in clusters as a function of cluster size.



Thanks, Phil

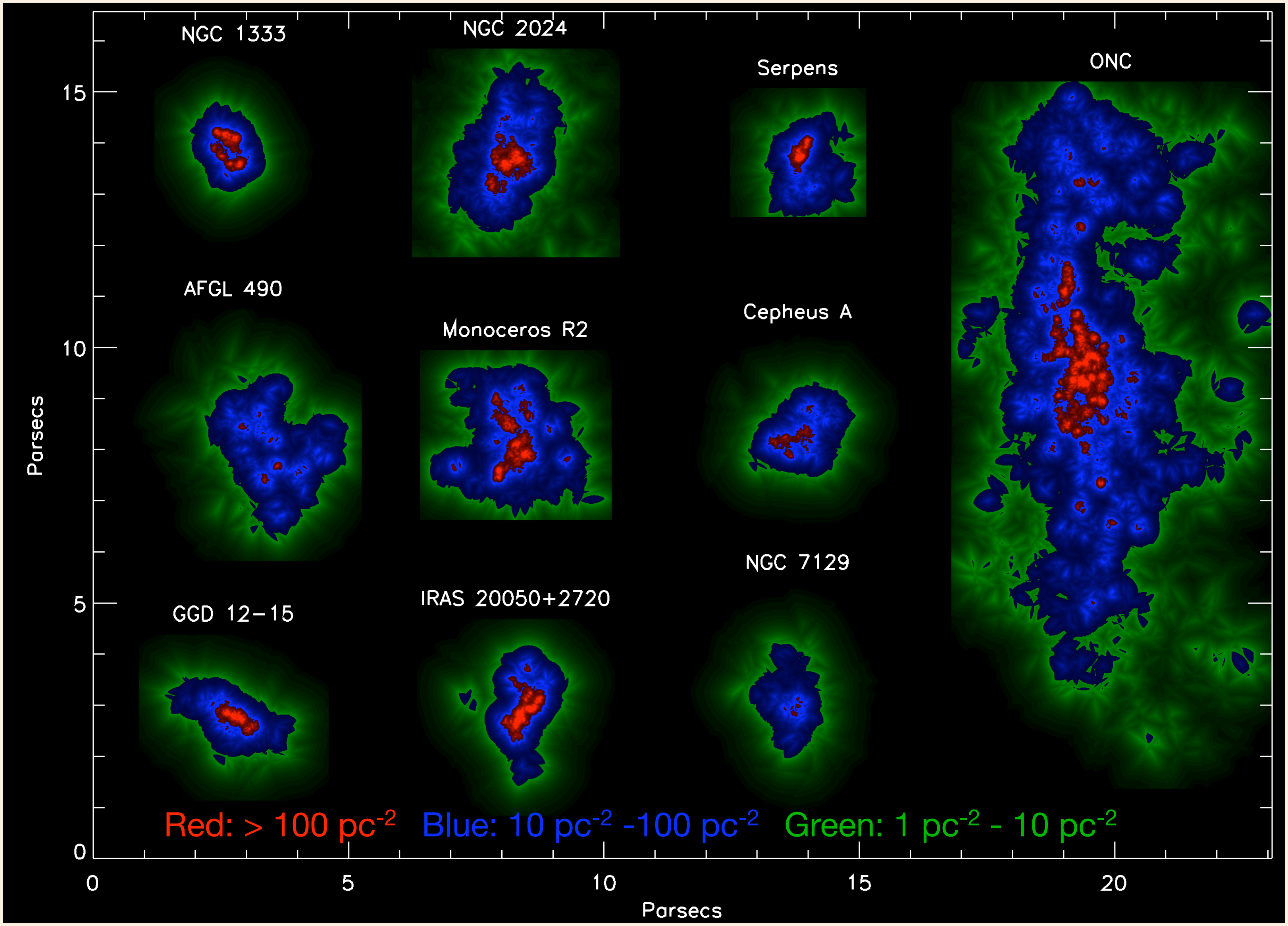

NASA SMALL EXPLORER
WIRE
SPITZER
SPACE TELESCOPE
WIDE-FIELD INFRARED EXPLORER

Some questions.....

Clusters as distinct objects versus nested clustering extending from complex scales down to ~0.1 pc sub-groupings.

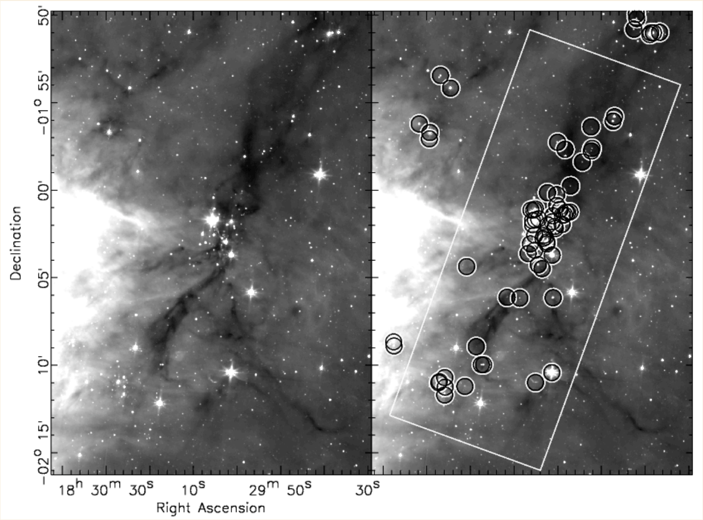
Brainstorm: how many different ways can we explain the observed surface density of YSOs versus gas trend?

Surface Density Maps of Young Clusters (Gutermuth)



Cluster structure: not spherical

Discovered in Gould Belt Legacy Survey



- Protostar-dominated cluster
- Follows dark filament
- High density (480 YSOs / sq. deg.)

==> Likely probing primordial cluster structure.

(Gutermuth et al. 2008)