Massive Stellar Clusters in the Galaxy: Multiwavelength Observations of New Candidate Clusters

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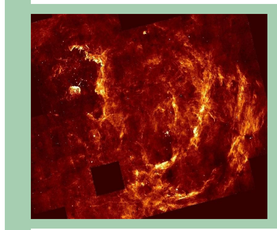
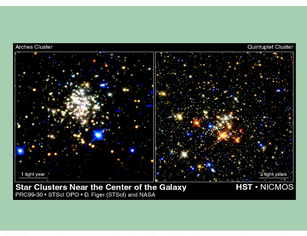
Massive clusters we know: in the Galactic Center

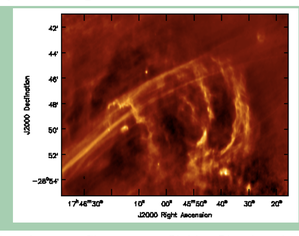
Massive stars return a significant fraction of their mass to the interstellar medium (ISM), by mean of stellar winds and supernovae explosions.

Several massive clusters (> 10,000 solar masses), are known and well-studied in the Galaxy (e.g. Arches, Quintuplet, Westerlund 1 and 2).

The Arches and Quintuplet clusters are thought to be responsible for the ionization and sculpting of the surrounding ISM: the Sickle and the Arched Filaments are ionized by these two massive clusters, which lie at the center of curvature of the filamentary structures. These massive clusters produce 10^{50-51} photons s^{-1} each and are likely within 10 pc of the gas. Stellar winds from the most massive stars are found to have mass-loss rates exceeding 10^{-5} solar masses year (Lang et al. 2001, 2005).





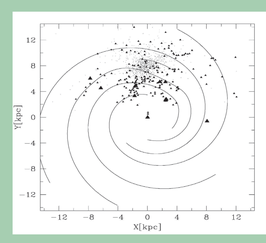


(left) Hubble Space Telescope/NICMOS Pa-α image of the Radio Arc region, showing the very filamentary Sickle, Pistol and Arched Filaments streamers of ionized gas (unpublished from Wang, Dong, Lang, Stolovy, Cotera et al). (middle) HST/NICMOS image of the Arches and Quintuplet clusters from Figer et al. (1999). (right) VLA 4.9 GHz radio continuum image of the Radio Arc region showing the impact of these clusters on the ISM (from Lang, unpublished survey of the GC).

Finding more massive clusters in the Galaxy

The number of known Galactic massive clusters may well be incomplete. Recent infrared (IR) observations made with 2MASS and Spitzer/GLIMPSE have revealed ~1000 new candidate stellar clusters (e.g. Bica et al. 2003, Mercer et al. 2005, Froebrich et al. 2007), and upcoming IR Galactic surveys UKIDSS and VISTA may reveal even more.

Using a compilation of about 500 Galactic candidate clusters **we have selected a sample of 40 highly-possible candidate massive clusters.** The selection was based on the combination of DSS2, 2MASS, MSX, Spitzer/GLIMPSE and VLA-NVSS survey data. The appearance of the clusters of stars and of their surroundings at different wavelenghts gives information on the extinction, on the presence of remnants of natal dust (hence clusters that are recently-formed). *The presence of diffuse continuum radio emission* indicates the presence of OB stars and can provide useful estimates of the (1) Lyman continuum flux of the stellar cluster, (2) the electron density and total mass of the ionized gas, (3) stellar wind emission (for point sources able to be resolved), and (4) the morphology of the impacted surrounding ISM.



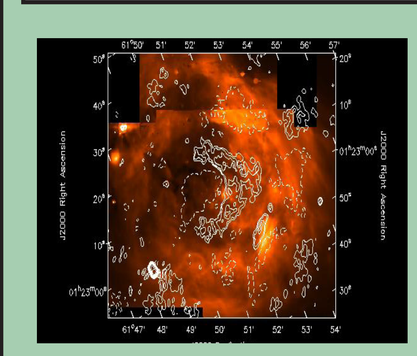
Dots represent clusters detected in the optical from catalog of Dias et al. (2002). Triangles are for the candidate clusters. In the latter case, distances are the kinematic distances of the associated HII regions from Kuchar et al. (1994). The rotation curve is from Brand and Blitz (2003). Big triangles represent clusters with masses > 5000 solar masses.

These Observations

- August 2008
- VLA in D-array
- 8.5 and 4.9 GHz
- resolution: 5-20"

We selected 6 of the 40 candidate clusters that had NVSS radio emission as well as IRAC/Spitzer imaging in all four bands (PI for Spitzer: D. Figer).

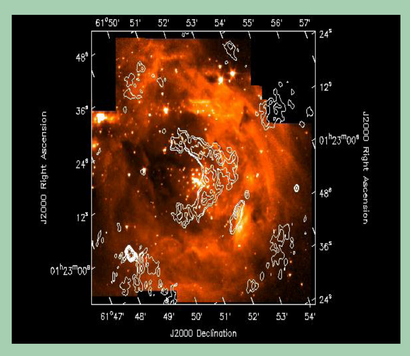
Bica Dutra 2003 #52: Sharpless 187



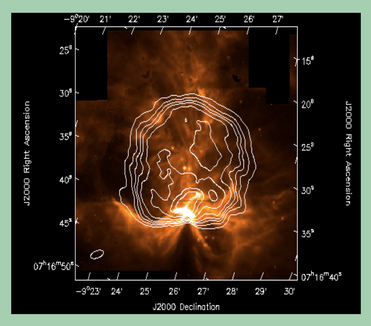
Distance: 1.0 kpc (Joncas et al. 92)

(left) colorscale shows distribution of 8.0 μm emission from IRAC/Spitzer with 8.5 GHz radio contours overlaid

(right) colorscale shows 3.6 μm emission from IRAC/Spitzer with contours showing 8.5 GHz radio emission



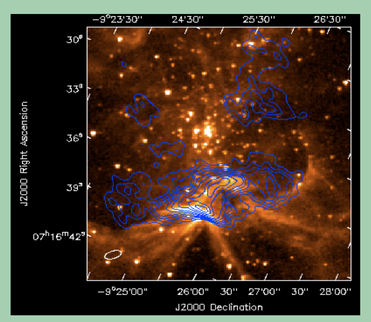
Bica Dutra 2003 #95: G224.2+1.2



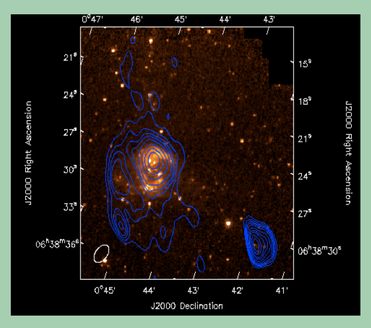
Distance: 3.25 kpc (Kuchar et al. 94)

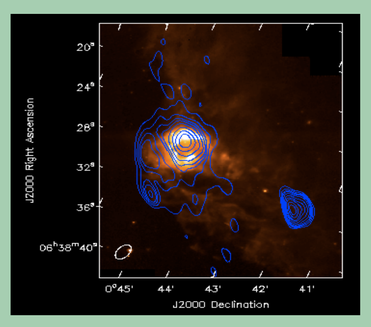
(left) contours shows 4.9 GHz emission and colorscale shows 8.0 μm from IRAC/Spitzer

(right) contours of total intensity at 8.5 GHz emission and 3.6 μm from IRAC/Spitzer



Bica Dutra 2003 #84: G210.8-2.6





Distance: 7.75 kpc (Kuchar et al. 94)

(left) contours of 4.9 GHz emission and colorscale showing 4.5 μm from IRAC/Spitzer

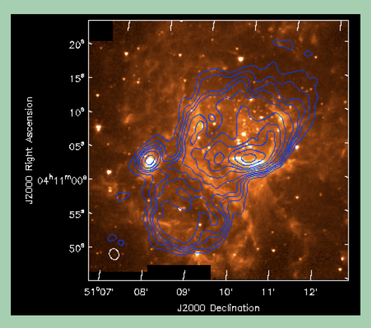
(right) contours of 4.9 GHz emission and colorscale showing 8.0 μm from IRAC/Spitzer

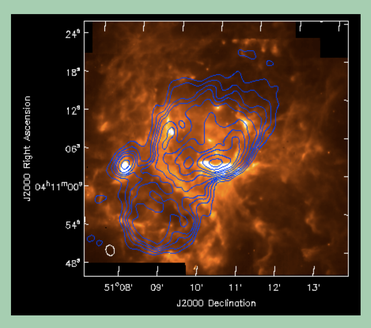
Bica Dutra 2003 #65: G151.6-0.2

Distance: 8.75 kpc (Kuchar et al. 94)

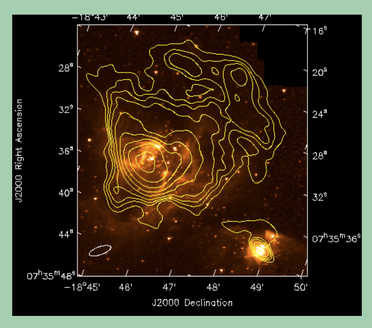
(left) radio contours of 4.9 GHz resolution and colorscale of 3.6 μm from IRAC/Spitzer

(right) radio contours of 4.9 GHz and colorscale of 8.0 μm from IRAC/Spitzer





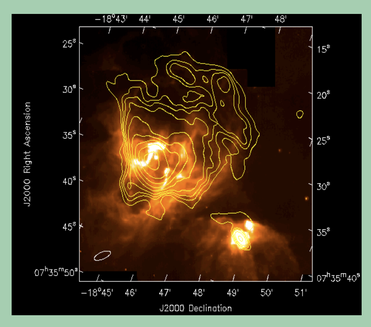
Dutra Bica 2003 #7: Sharpless 2-307/G234.6+0.8



Distance not known

(left) Contours of 4.9 GHz radio emission overlaid on colorscale showing 3.6 μm from IRAC/Spitzer

(right) Contours of 4.9 GHz radio emission overlaid on colorscale showing 8.0 μm from IRAC/Spitzer

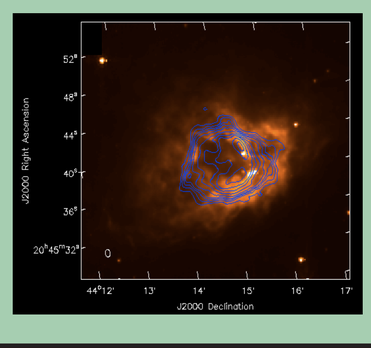


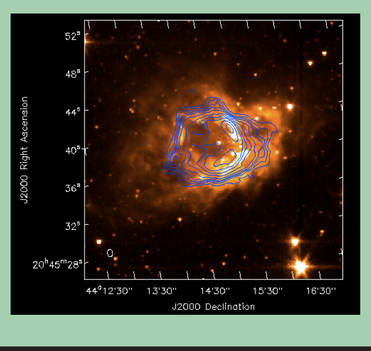
Dutra Bica 2001 #23: G84.0+0.8

Distance: 3.5 kpc (Comeron et al. 2005)

(left) Contours of 4.9 GHz radio emission overlaid on colorscale showing 5.3 μm from IRAC/Spitzer

(right) Contours of 4.9 GHz radio emission overlaid on colorscale showing 3.6 μm from IRAC/Spitzer





Radio Continuum Parameters

These parameters are derived using the formulae of Mezger & Henderson (1967) for a spherical HII region of uniform density, $\tau << 1$, T~10,000 K.

Sources	Radio Flux Density (Jy)	D (kpc)	Linear Radius (pc)	n_e (cm^{-3})	EM (pc cm^{-3})	Mass HII (M_o)	N_{Lyc} (photons s^{-1})
DB #23	2.40	3.5	1.2	190	9.8×10^4	39.8	2.6×10^{48}
BD #95	0.25	3.25	2.0	29	2.9×10^3	24.4	2.3×10^{47}
BD #95 - core	0.030	3.25	0.7	53	3.9×10^3	1.7	3.0×10^{46}
BD #84 - main	0.024	7.75	1.8	25	2.3×10^3	15.1	1.3×10^{47}
BD #65 - main	2.20	8.75	3.2	120	9.0×10^4	337.0	1.5×10^{49}
BD #65 - West	0.40	8.75	2.3	84	3.3×10^4	95.6	2.7×10^{48}
BD #52* (flux missing)	0.04	1.0	0.2	110	5.2×10^3	0.1	3.8×10^{45}

Future Work

These results are preliminary and we will be undertaking a more thorough look at our data during the next phase of the project. This will include:

- Determining spectral index (although much extended flux is missing in some cases)
- Determining physical properties of ionized gas (as above, but with better constraints)
- Determining properties of stellar clusters with near-infrared CMD and spectra
- Careful comparison of morphology between radio and infrared images
- Multi-wavelength analysis of interstellar bubbles (with X-ray and infrared properties)

In addition to radio emission associated with these 6 candidate clusters, we will be mining the VLA and MAGPIS archives for radio counterparts to other candiate clusters.