Mid-Infrared Bubbles: Gas Structure and Star-Formation Analysis

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Abstract

We use 4 surveys (see Table 1) to determine the gas structure and YSO population surrounding 3 IR bubbles. The bubbles were selected from the catalog of Churchwell et al. (2007) which were identified in the GLIMPSE-II 8 μm images. The 3 bubbles are likely produced by late-O or early-B stars ionizing their immediate surroundings, heating large dust grains and exciting a shell of PAHs. We use a SED-fitting, χ^2-minimization technique using numerical radiative transfer models to identify the YSO population and measure their physical properties. We detect a significant YSO population toward the two powerful bubbles. We also identify candidate ionizing stars based on IR colors and luminosity.

Table 1: Surveys Used

Mission	Longitude	λ	Instrument
GLIMPSE-II	$-10^{\circ} \rightarrow +10^{\circ}$	3.6 μm, 4.5 μm, 5.8 μm, 8.0 μm	Spitzer-IRAC
MIPSGAL-II	$-10^{\circ} \rightarrow +10^{\circ}$	24 μm	Spitzer-MIPS
MAGPIS	$-10^{\circ} \rightarrow +42^{\circ}$	20 cm, 6 cm	VLA
2MASS	All	1.25 μm, 1.65 μm, 2.17 um	Two 1.3-m telescopes

CN 108

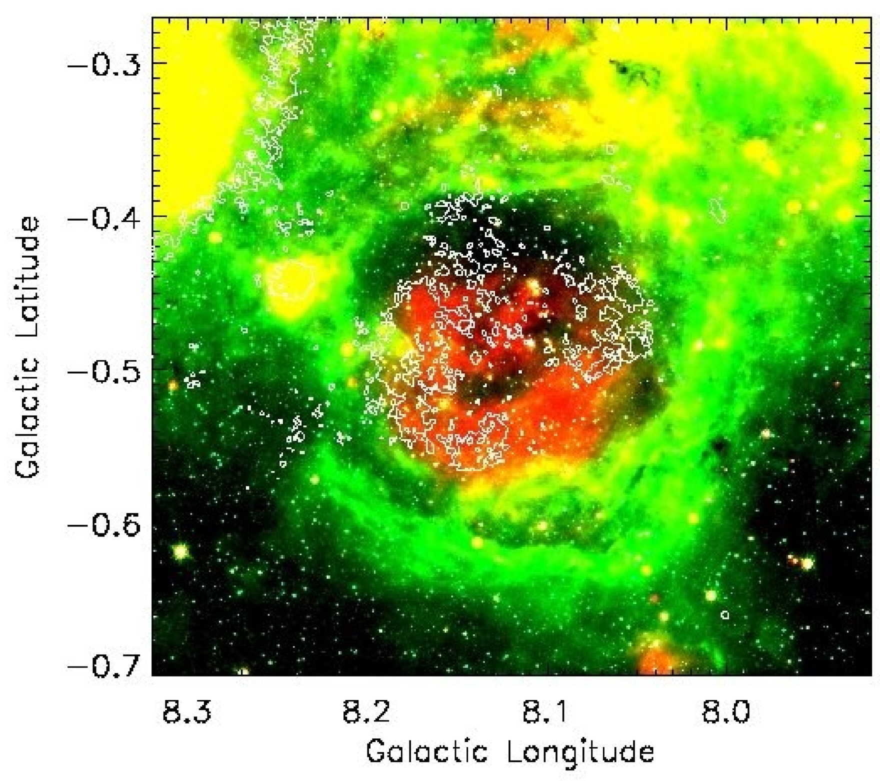

Fig 1: 4.5 μm (stellar-dominated), 8.0 μm (PAH-dominated), 24 μm (hot dust-dominated) and 20 cm (ionized gas) in contours. The 20 cm emission is equivalent to a O8 star or earlier. The kinematic distance is 4.9 kpc. The radius is 340" (12 pc).

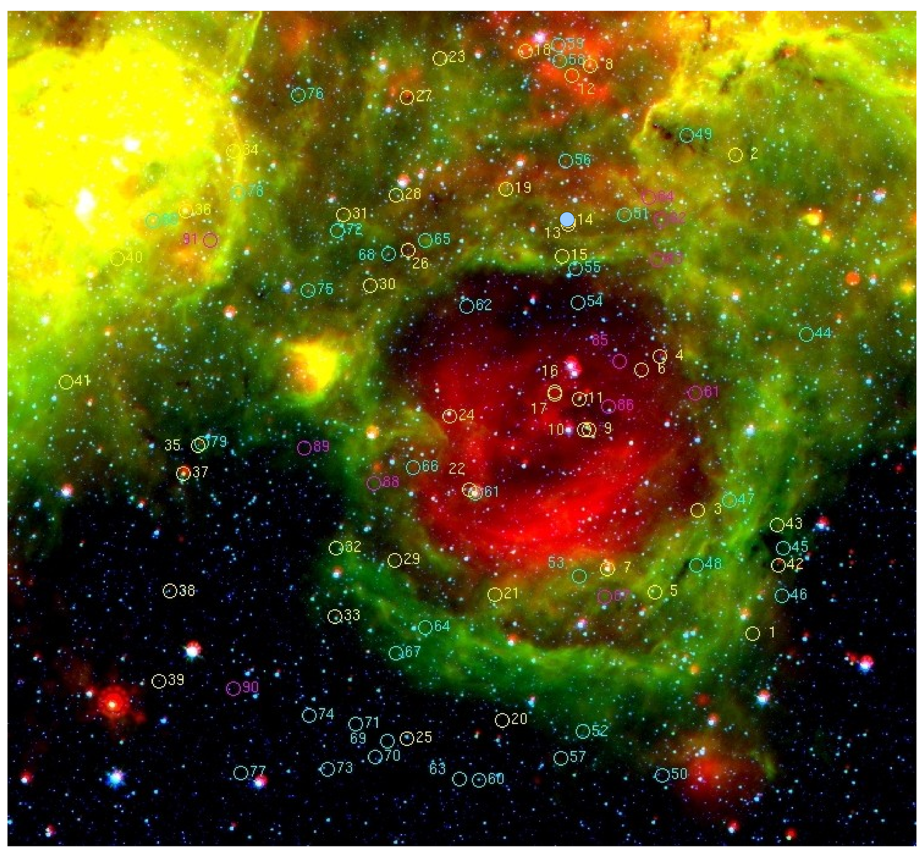

Fig 2: 4.5 μm, 8.0 μm & 24 μm emission. Circles indicate YSOs in stage 1, stage 2 and stage 3, using the criteria of Robitaille et al. 2007.

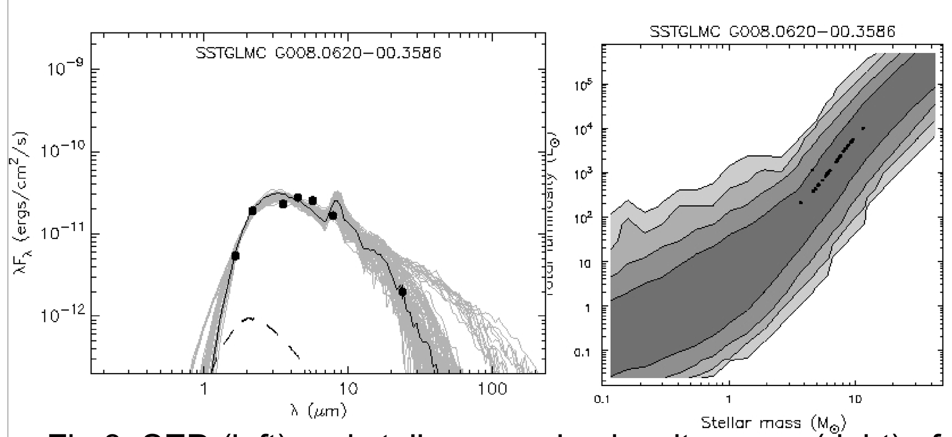

Fig 3: SED (left) and stellar mass-luminosity range (right) of the solid YSO in figure 3. Well-fit numerical radiative transfer models are shown in gray (left) and as dots (right).

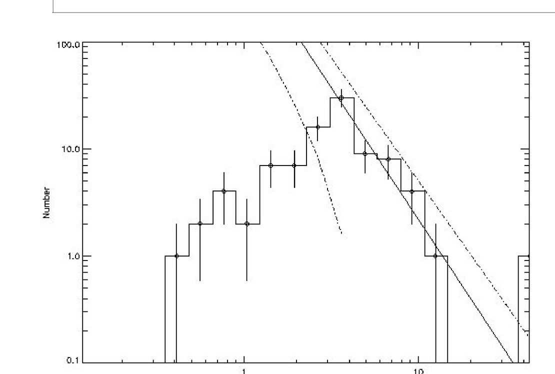

Fig 5: Mass function of the YSO population. The high-mass end has a best-fit slope Γ=-1.5 ± 0.6.

CN 138

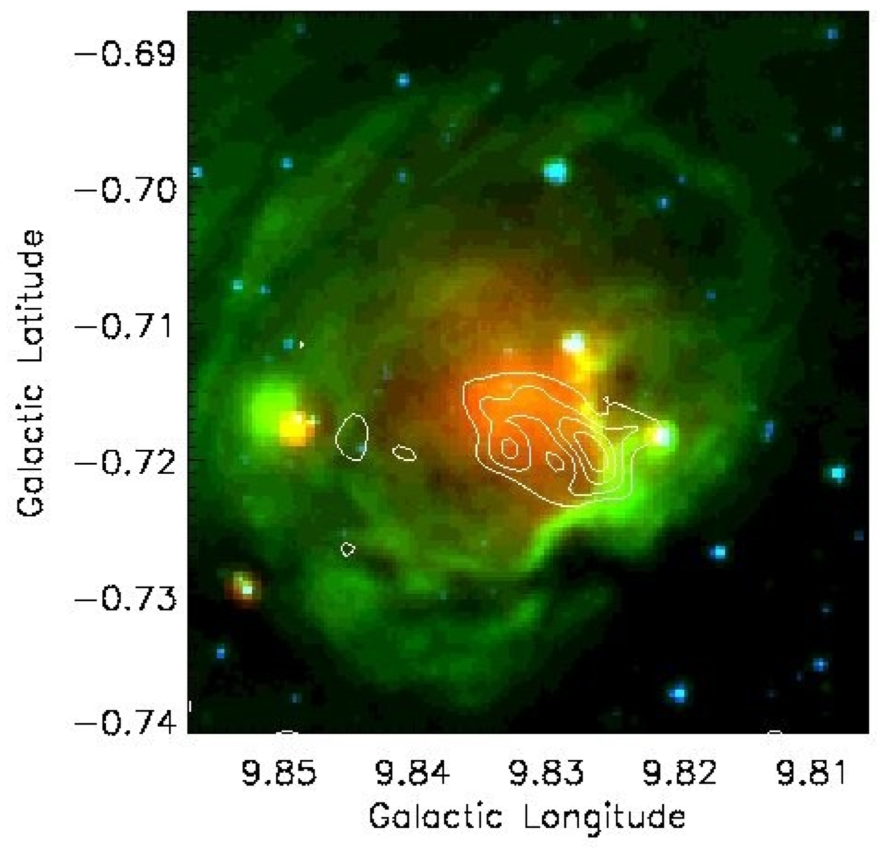

Fig 4: Same as fig 1. The 20 cm emission is equivalent to B0-0.5 star or earlier. The kinematic distance is 4.3 ± 0.6 kpc. The radius is 80" (1.7 pc).

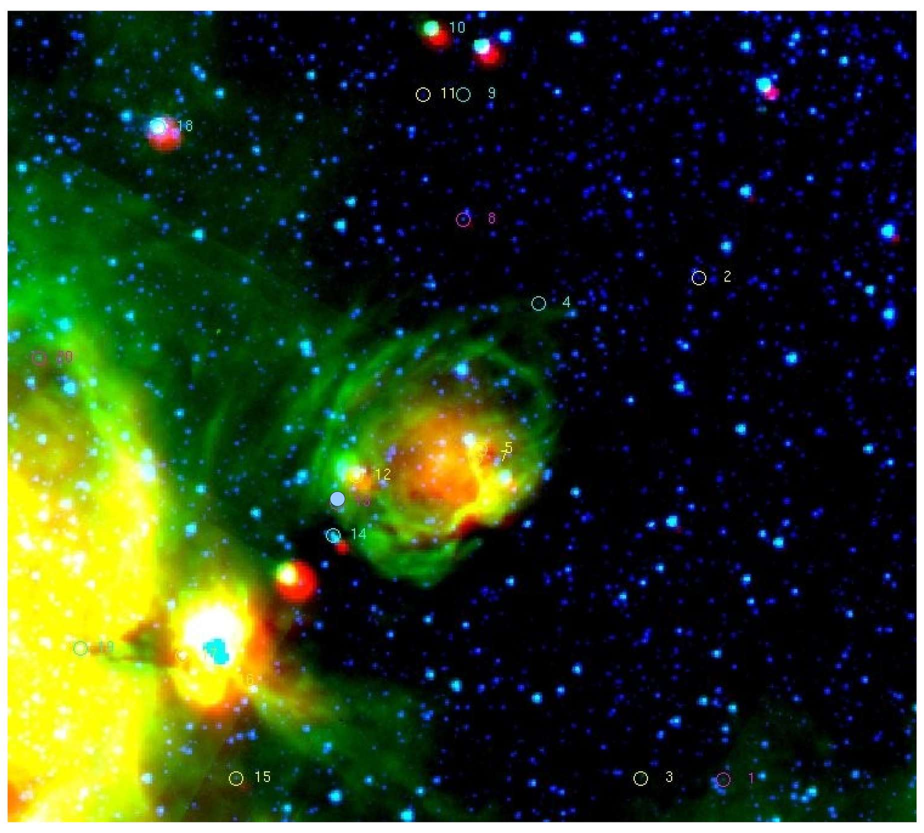

Fig 5: Same as fig. 2

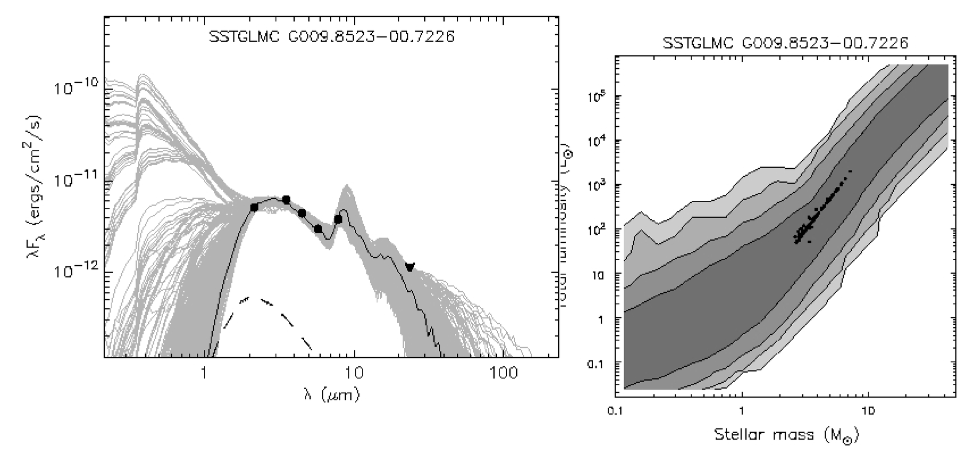

Fig 6: Same as fig. 3

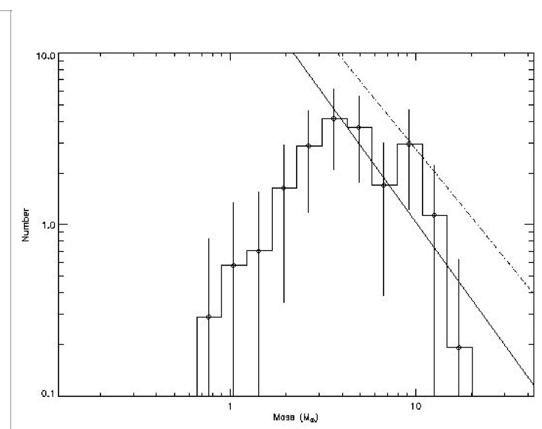

Fig 9: Mass function of the YSO population. The high-mass end has a best-fit slope Γ=-2.5 ± 0.5.

CS 57

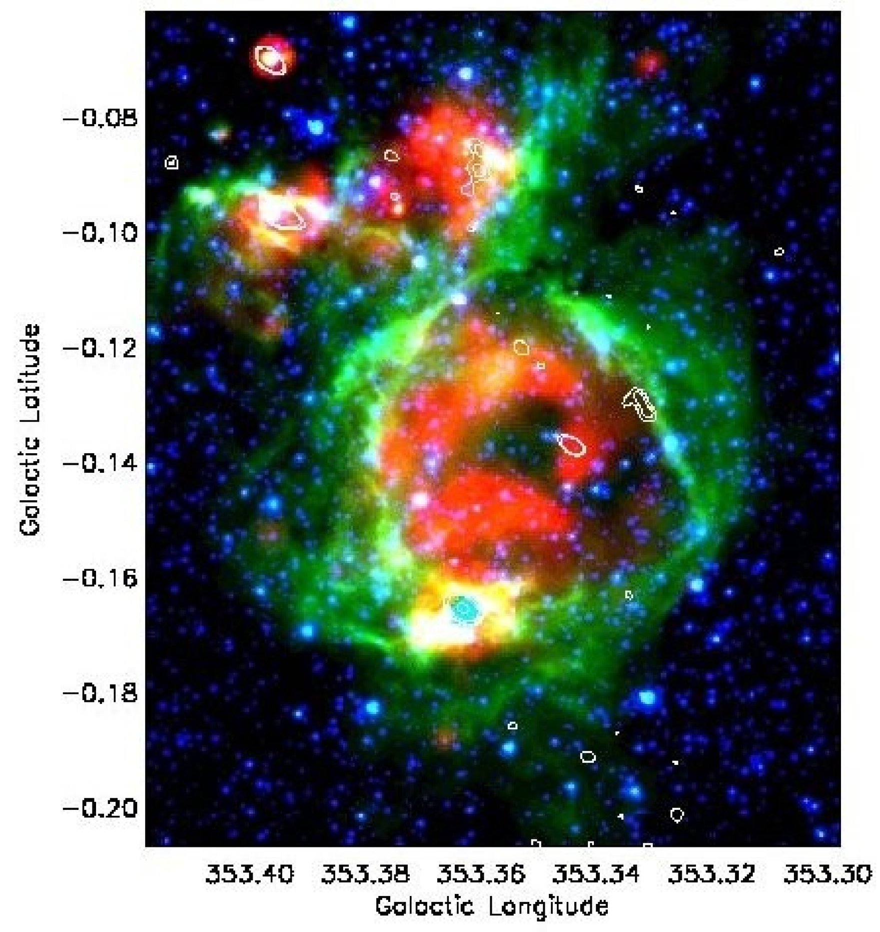

Fig 7: Same as fig 1. The near kinematic distance is 6.2 kpc. The radius is 81" (4.9 pc).

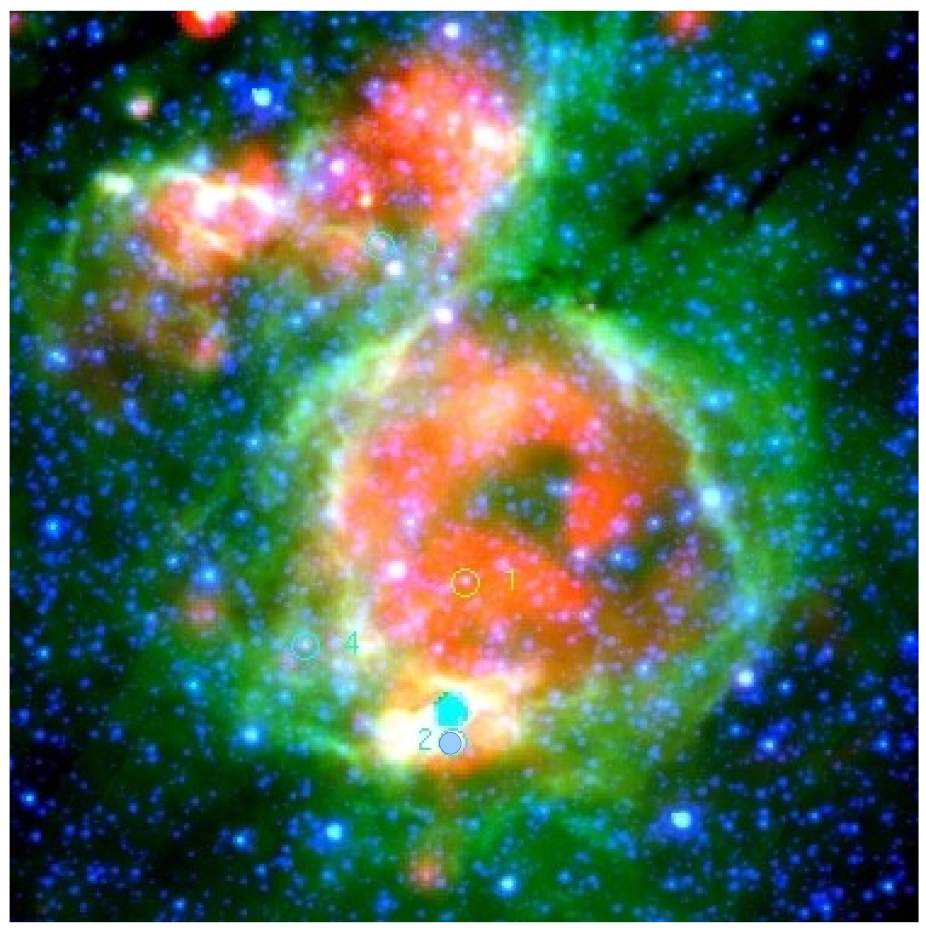

Fig 8: Same as fig. 2

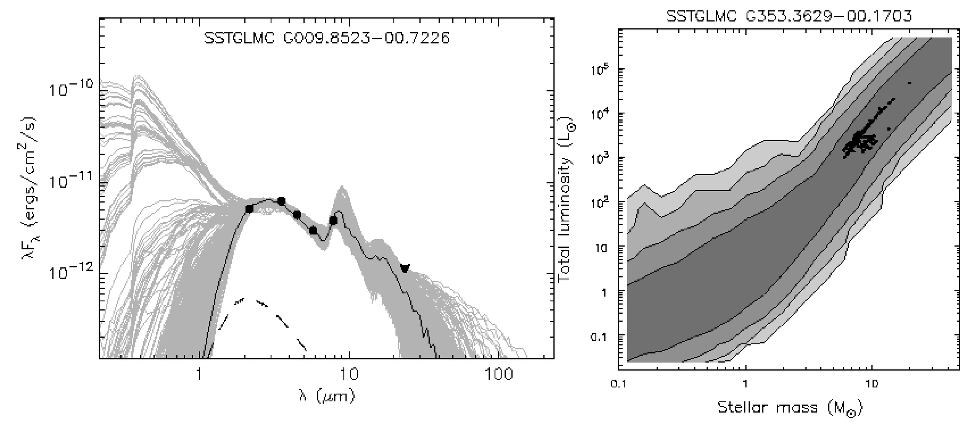

Fig 9: Same as fig. 3

Conclusions

- In all 3 bubbles PAHs surround hot dust.
- In 2 bubbles PAHs surround ionized gas.
- We detect 20, 91 & 4 YSOs in CN138, CN108 & CS57, respectively.
- In CN108 & CN138 YSOs may have formed due to material being compressed by UV-radiation and stellar winds from hot, central star(s).
- In 2 bubbles ionizing star candidates were identified
- In CN108 & CS57 the 24 μm emission is shell-shaped, possibly indicating stellar-wind blown hot dust.

Table2: YSO Population

ID	Mass best	Mass min	Mass max	Luminosity best	Luminosity min	Luminosity max	Mass Change best	Mass Change min	Mass Change max
CN108-86	38.0	17.3	49.6	333700	37170	376600	3.80E-3	1.11E-3	4.94E-3
CN108-48	14.0	11.3	23.7	19060	9714	70880	0	0	0
CN108-23	10.0	8.0	16.2	4035	2714	17220	2.24E-3	0	6.90E-3
CN108-26	9.2	2.3	10.7	4922	81	4922	1.58E-4	0	7.44E-4
CN138-5	1.9	0.3	6.3	36	5	1100	9.14E-5	0	5.38E-4
CN138-7	2.4	0.7	10.5	55	8	2306	1.36E-4	0	2.10E-3
CN138-12	2.4	1.0	6.5	60	24	331	1.14E-5	4.18E-7	1.44E-3
CN138-13	4.4	2.7	7.3	292	49	1942	0	0	0
CS57-1	7.3	1.0	11.6	443	110	10020	4.13E-5	0	1.62E-3
CS57-2	13.0	6.0	20.0	13420	993	46230	0	0	4.03E-3
CS57-3	5.1	2.3	11.5	517	85	5111	0	0	2.74E-3
CS57-4	5.2	3.7	11.6	533	152	9883	0	0	1.75E-3

Table3: Driving Star Candidates

Source	Type
CN108	
G8.0903-0.4912	O7
G8.1090-0.5168	O9.5
G8.1375-0.4282	O9.5
G8.1541-0.4920	O6
G8.1565-0.4337	O7.5
G8.1566-0.5274	O7
CN138	
G9.84200-0.7134	O8.5
G9.8421-0.7127	O9
CS57	
G353.3171-0.1416	O6.5
G353.4059-0.1466	O6.5

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Bibliography:

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