

Runaway Massive Stars, Bow Shocks and the Case of the Nebula NGC3199

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(w/J.A. Toalá, ASIAA, Taiwan; and Instituto de Radioastronomía
y Astrofísica, UNAM, Mexico)

Based on: Toalá, Marston et al, 2017, ApJ, 846, 76.

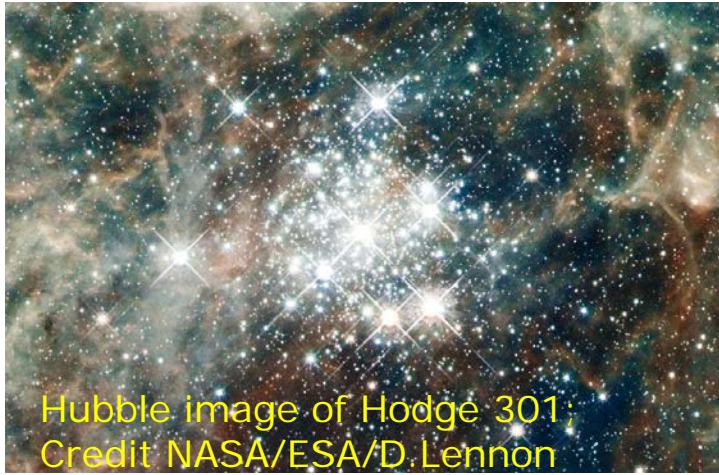
Overview



- Introduction
 - Clusters
 - Massive star distribution
 - Possible resolutions
- The nebula NGC3199 and the Wolf-Rayet star WR18
- GAIA results
- General conclusions and future



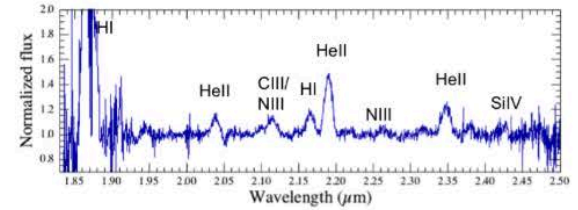
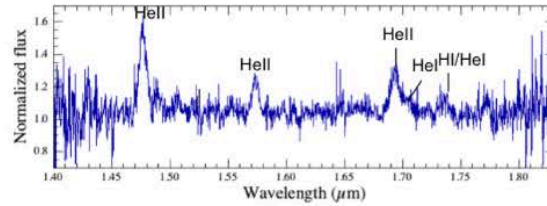
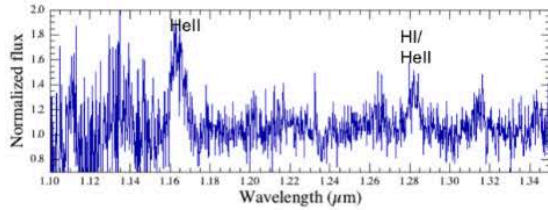
Massive Stars in Clusters



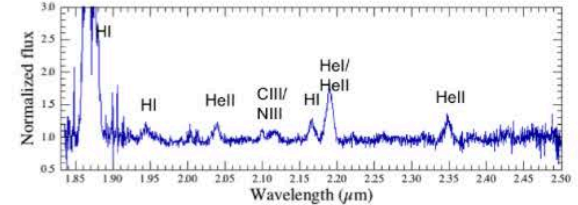
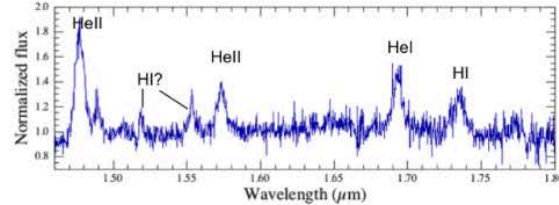
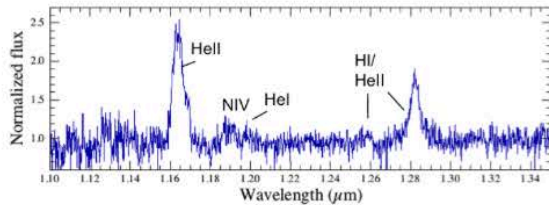
Dense young clusters – stars up to a few million years old. O/B stars and **Wolf-Rayet stars (evolved from most massive O stars $>20M_{\odot}$)**

Galactic Wolf-Rayet IR Spectra (finding [obscured] objects)

2MASSJ18282046-1216364 (WN4-5)



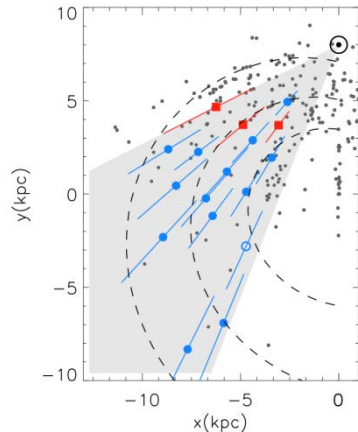
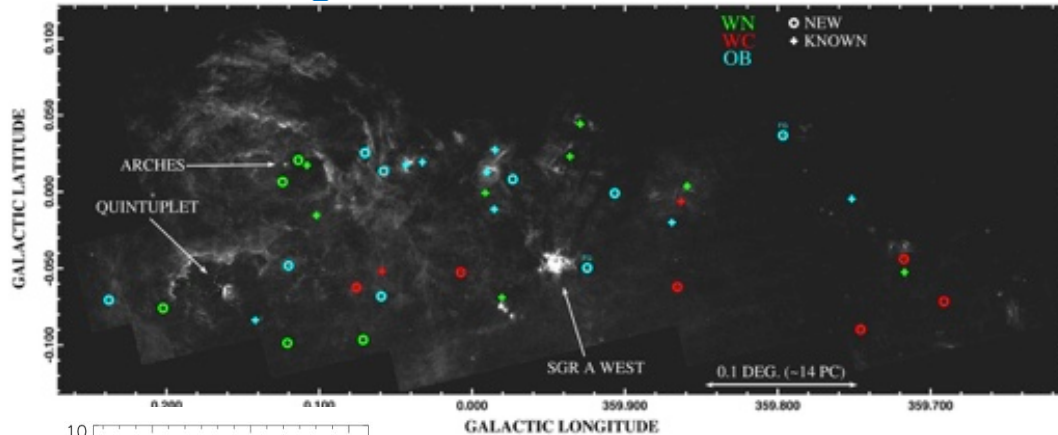
2MASSJ18442065-0236510 (WN4-5)



IRTF data:

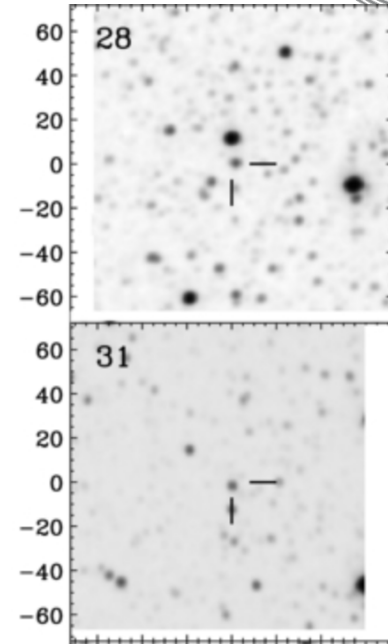
from Morello (+Marston)+ 2018, MNRAS, 473, 2565

A Scattering of Massive Stars... an inconvenient truth?



Massive stars scattered
across inner galaxy;
Mauerhan+ 11a

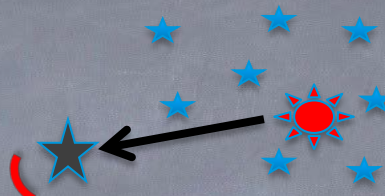
> 300 Wolf-Rayet stars
distribution, **only 25%** in
clusters or near HII regions;
Rosslowe & Crowther, 2017



"Isolated" Wolf-Rayet
stars;
Mauerhan+ 11b



Possible causes of apparent isolation

Massive star expulsion from young clusters.
Binaries in SNe?



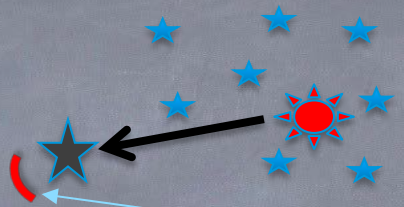
Low mass clusters
 $\sim 10^2 - 10^3 M_{\odot}$.

Distributed/more isolated
– e.g. via triggered SF.




Expulsion and bow shocks

Massive star expulsion from young clusters.
Binaries in SNe?



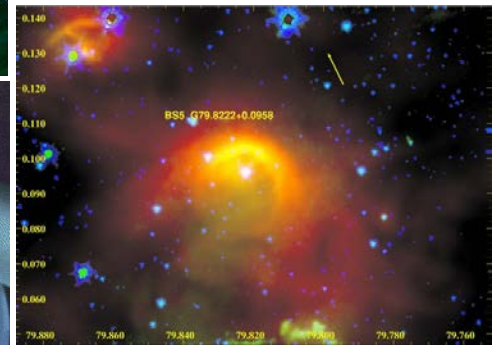
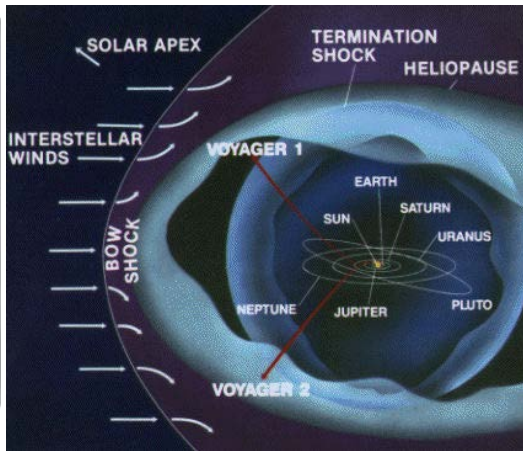
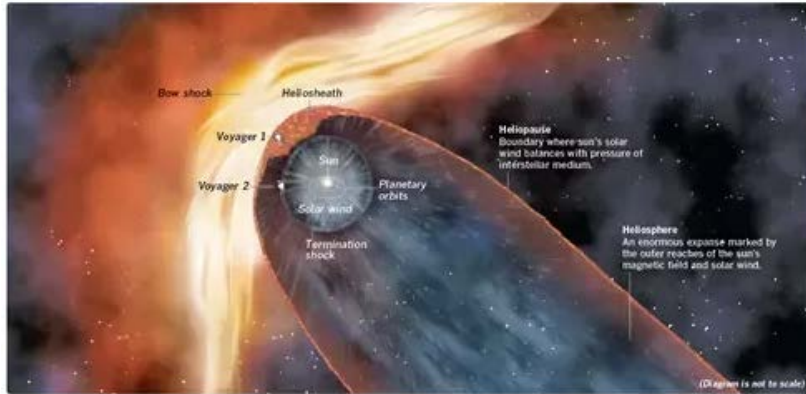
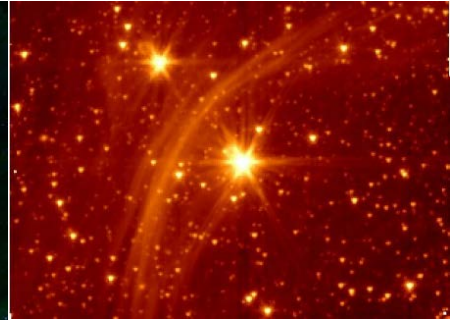
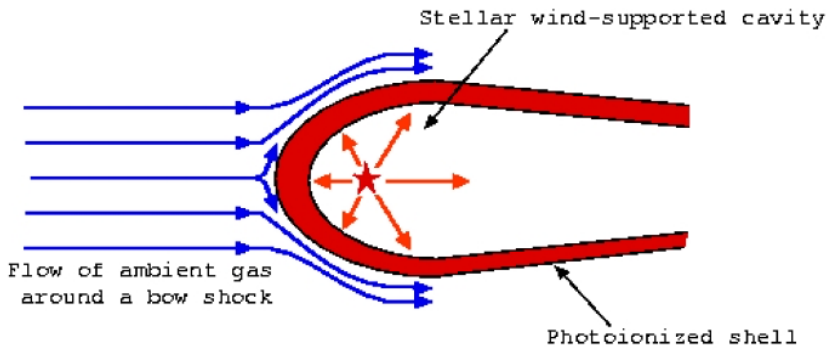
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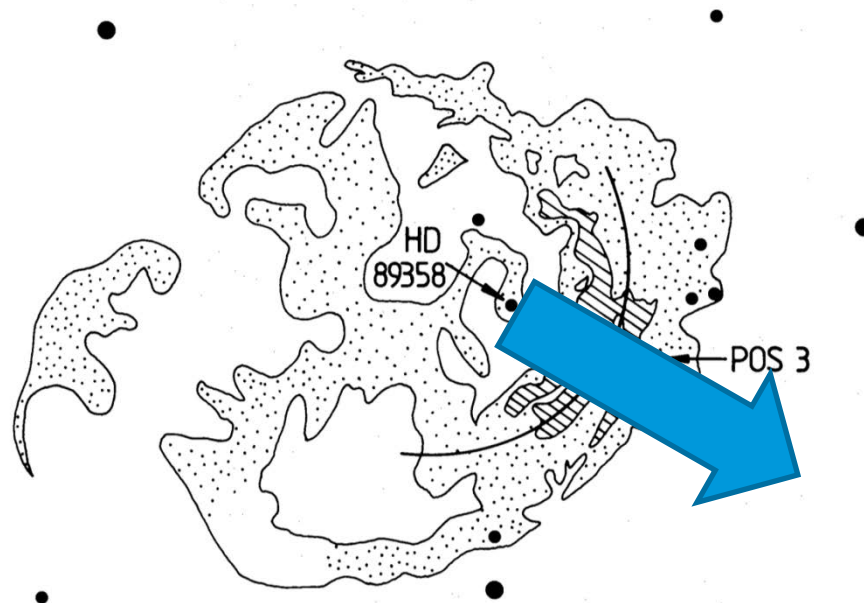
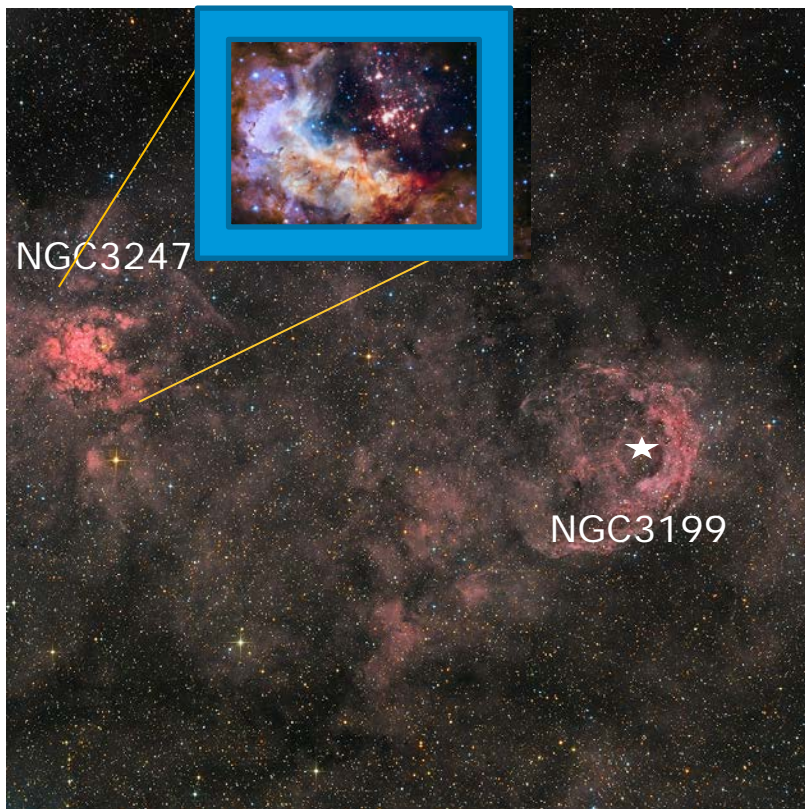
'Bow shock'

Bow shock examples



Kobulnicky+,
10, 16;
Peri+ 15

NGC3199 (nebula) and WR18 (star)



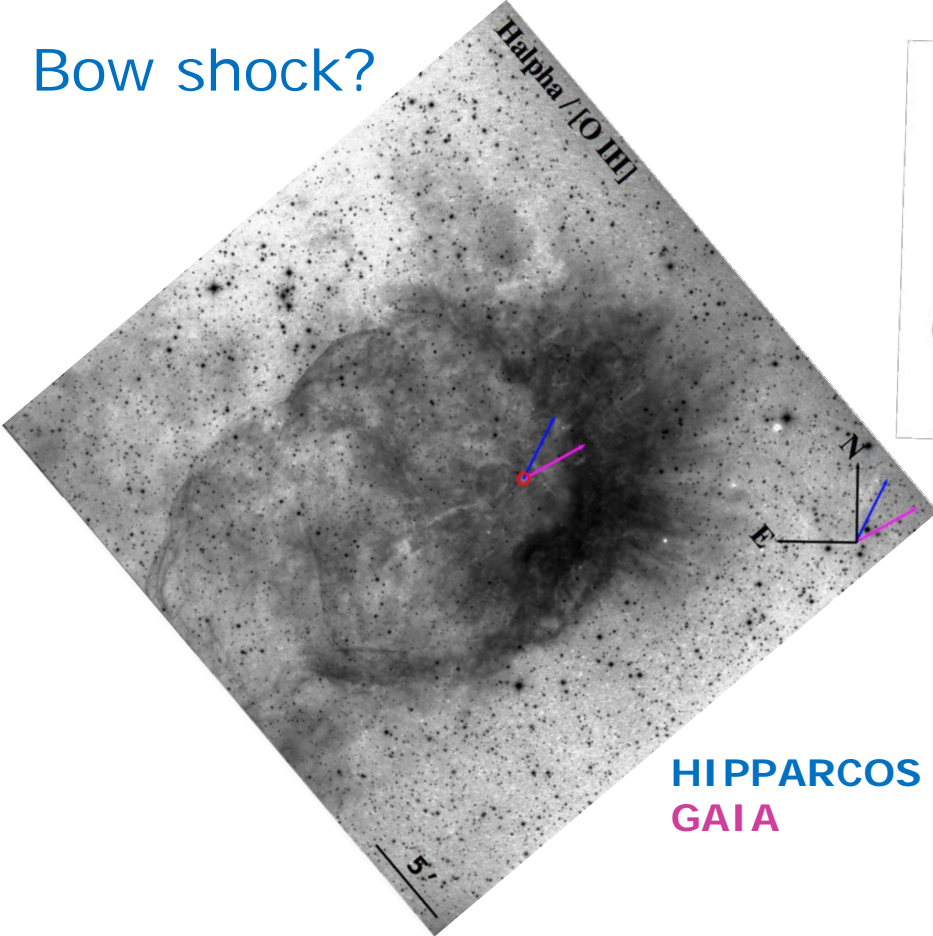
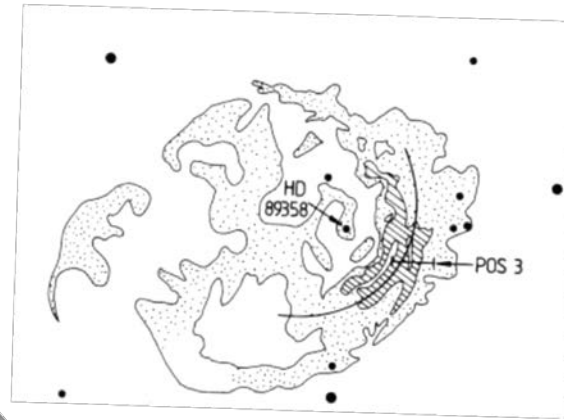
WR18=HD89358. Dyson & Ghanbari (1989) modelled nebula as a bow-shock created by the strong wind of the star as it travelled at 60km/s to south-east.

NGC3247 -- Westerlund 2

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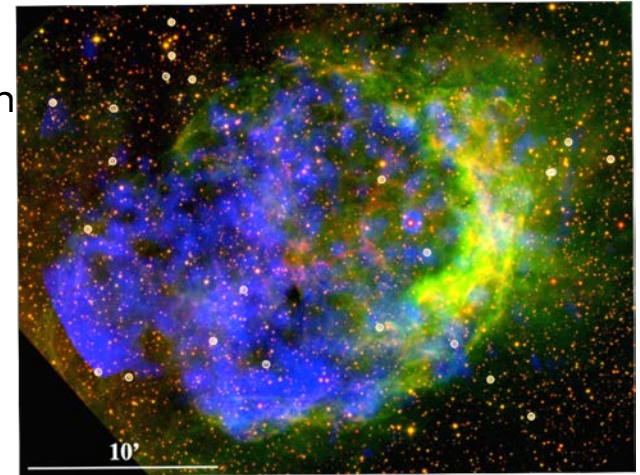
Bow shock?

- Investigated as a bowshock in front of WR star moving at 60km/s – **Dyson & Ghanbari 89**

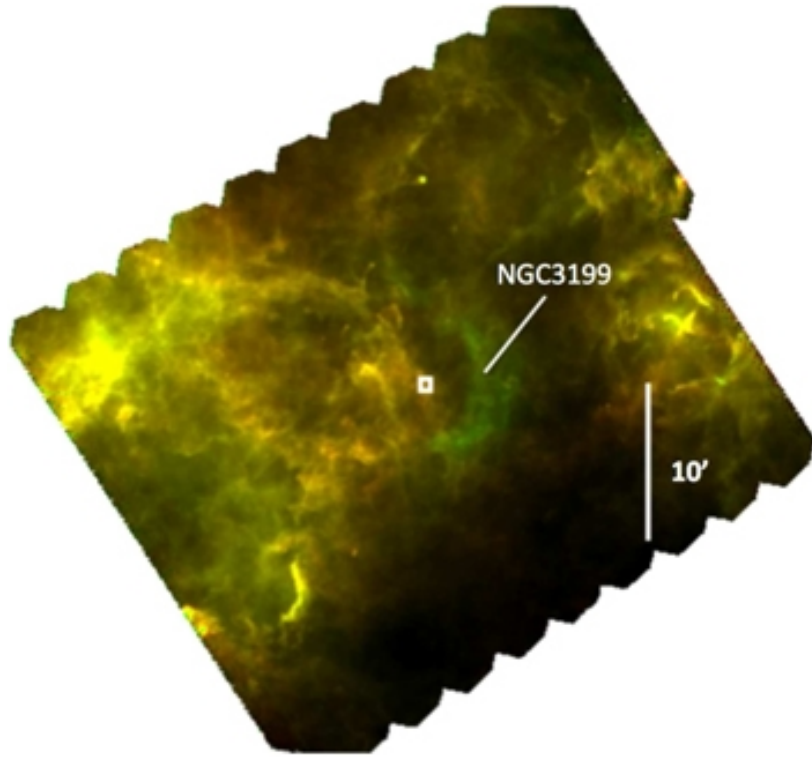


HIPPARCOS
GAIA

Stars with similar proper motions



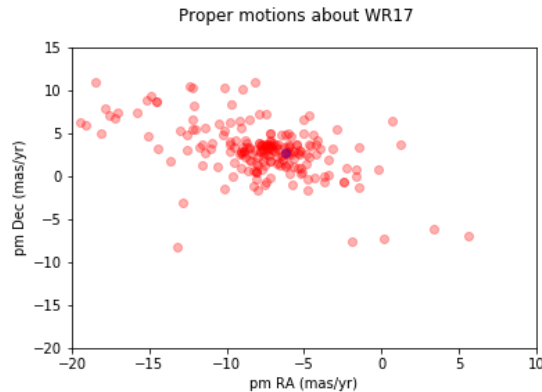
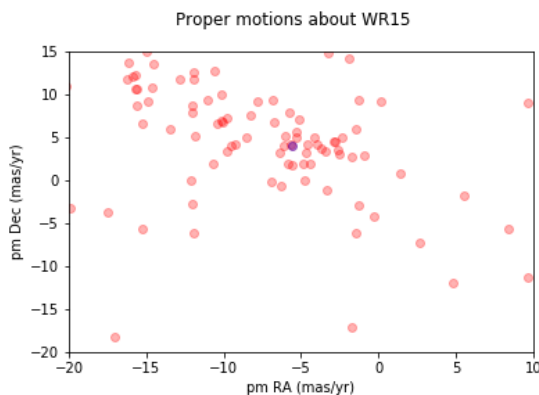
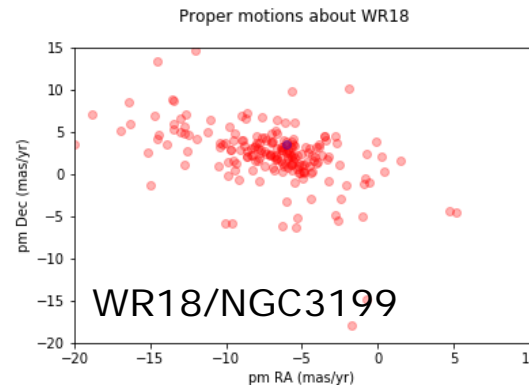
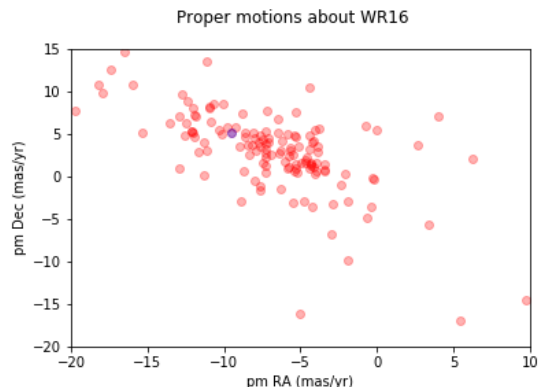
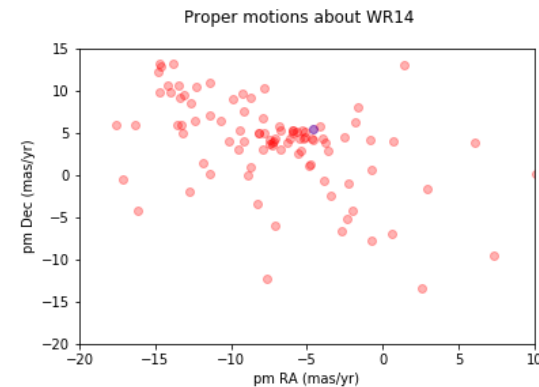
Herschel view of the NGC3199 field



Two color *Herschel* PACS (Observation ID: 1342249269; PI: A. Marston) far-infrared image at **100 μm (green)** and **160 μm (red)** wavelengths.

The main nebula NGC 3199 exhibits an arc of high 100 to 160 μm fluxes indicative of hot dust. The position of WR18 is shown by the white box at center.

Early results: Wolf-Rayet Proper Motions from GAIA DR1



Summary



- The proper motion of the WR star does not fit the direction needed for a bow shock. Indeed, more than 50% of the TGAS stars in the region from GAIA DR1 have similar proper motion.
- WR18 is not the most isolated of WR stars but not in a cluster and appears not to be coming from a cluster.
- Need a broader study to determine the prevalence of massive star 'runaways' in the early evolution of stellar clusters.
- Deep imaging shows the flow of the wind through dense parts of NGC3199 → mass-loaded wind.

Future?:

Information limited in DR1. More proper motions needed and for fainter stars local to massive stars.

Await GAIA DR2.

Search for small, dense clusters around WR stars.