Skyscrapers in a Desert: Observing Ongoing, Active Star Formation in the Low-Density Wing of the Small Magellanic Cloud

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What’s going on here?

The low-density Wing of the Small Magellanic Cloud (SMC) exhibits ongoing, active star formation despite a distinctive lack of dense interstellar matter, or resources from which to form stars1,2. The region appears as if you found skyscrapers in an empty desert: there are clear signs of production without an obvious source of materials. Given such paradoxical star formation, the Wing and its most significant star cluster NGC 602 have long been regarded as isolated laboratories in which to study low-density, primordial star formation3,4. However, our photometric observations surrounding NGC 602 reveal a far more complex and interconnected star formation history than may have been previously recognized: as though we observe an entire city surrounding these previously isolated “skyscrapers.”

We seek to more clearly describe this complex history and to ultimately determine if the observed star formation in the greater SMC Wing is indeed connected to that within the well-observed cluster NGC 602. In other words, is NGC 602 an anomalous skyscraper or part of a larger desert city?

What can we learn?

- Studying star formation in low-density environments can help us to more clearly define the necessary conditions for stellar birth.
- Given the narrative of NGC 602 as an ideal, isolated laboratory of low-density star formation, an extended study of the SMC Wing will expand our understanding of the environmental conditions that fostered its growth.
- Evidence for a sophisticated stellar history within the SMC Wing may suggest that low-density star formation is driven by interconnected star-forming complexes, rather than isolated, anomalous skyscraper events.

How did we investigate?

Near-Ultraviolet (NUV):
- Telescope: Galactic Evolution Explorer (GALEX)
- Mean wavelength: 232 nm
- Resolution: ~3 arcsec.
- Source extraction: IRAF DAOPHOT
- Distance correction: ~8.70 - d = 0.055 Mpc
- Extinction correction: ~0.42 - E(B-V) = 0.052
- Limitations: DAOPHOT could not resolve stars in high-density stellar clusters. As a result, they have not been included in this phase of the investigation.

Photometric Analyses

Color-Magnitude Diagram (CMD): CMDs relate the observed temperatures (color) and luminosities (magnitude) for stars of constant age, quantifying the relative age patterns in CMDs. In Figure 2, we see a significant population of NGC 602+ stars, with stars to the right of the main sequence plane giving evidence for evolved stars with a range of stellar ages (a desert city).

Isocline Models: Isoclines describe simulated temperatures (color) and luminosities (magnitude) for stars of constant age, in units of years. In Figure 2, we see a significant population of NGC 602+ stars, with stars to the right of the main sequence plane giving evidence for evolved stars with a range of stellar ages (a desert city).

What did we find?

Color-Magnitude Diagram and Isochrone Models

Figure 2 (Right): 
- Bright points: NUV vs. (NUV-V) CMD for ~1000 stars in NGC 602+
- Red tracks: Isochrone models for stars of fixed age (see legend), fixed metallicity ([Z/H] = -1.5), and varying mass (0.8 M☉ < M < 14 M☉).

Spatial Analyses

Figure 3 (Below): 
- Left: NUVo vs. (NUV-V) CMD highlighting three brightest-magnitude bins (see legend for bin magnitude ranges).
- Middle: Spatial plot showing the physical locations of stars according to their assigned bins.
- Right: Clustering analyses for all stars within NGC 602+.

High-Density Regions

Figure 4 (Most Right): 
- Image: MCELS No image of NGC 602+. Red circles: The two high-density clumps exhibited in Figure 3: Right, defined by a threshold clustering value of 2.05 (labeled Regions I and II).

What’s next?

- Our study reveals a far more extended, complex, and interconnected star formation history than has previously been assumed for the greater SMC Wing.
- Evidence for massive star formation throughout the SMC Wing and specifically beyond the star cluster NGC 602 encourages us to question the roles of both sequential and decentralized star formation in driving low-density stellar birth.

What does this mean?

- Further define the relationship between the stellar and gaseous components within this region. Did shell-shell collisions spark the trend of massive star formation in NGC 602+? What initiated shell expansion?
- Understand the impact that high-density star clusters have on our extended study (those too dense for our NUV source extractor to detect). Would inclusion of these clusters change our core results?
- Compare our photometric analysis with spectroscopic investigations of NGC 602+ (Ramachandran et al. in preparation).

References:
7. Bronf, 2001, JCAP, 2322, 0.

Acknowledgements: We respectfully acknowledge that during the 23rd AAS Meeting we are situated on traditional lands of the Pamunkey Indian Tribe and Pocahontas Indian Nation. We would like to thank the University of Potsdam Institute for Physics and Astronomy for supporting a visit to Potsdam, Robert Gwinner and Yoo-Hua Cho for their help with early imaging.