SOFIA Follow-up to Spitzer Observations of the North American Nebula

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ABSTRACT

Most of our current knowledge regarding star-forming patterns and circumstellar disk evolution derives from studies of molecular cloud complexes within a few hundred parsecs of the Sun, such as Taurus (140 pc) or Gum (600 pc). Studies of these two regions are the primary footnotes that inform our understanding of how stars form. However, the two environments are very different in many ways. Because the environment does matter, for a comprehensive understanding of star formation, it is important that we study more than just the nearest examples of the extrema of star formation modes. An example of “mixed-mode” star formation is the relatively nearby (~500 pc) North America (NGC 7000) and Pelican (NGC 7090) Nebula complexes (hereafter NAN). We observed the NAN with Spitzer (1-3 µm) and detecting a complex EM distribution and more than 700 point sources. In particular, the Gulf of Mexico in North America is revealed to be a dramatic cluster of this objects, seen at only 24°.

We obtained SOFIA data of the most confused portion of the Gulf cluster, using its higher spatial resolution at 25 microns to reveal more sources, and the addition of 35 micron data to better define the spectral energy distributions (SEDs) of several of these young stellar objects (YSOs). This should allow us to better characterize the properties of these YSOs and gain insight into some of the youngest objects in the NAN, as well as improve our understanding of the star formation process in dense regions such as this.

What is this Region?

- The NAN appears to exhibit “mixed-mode” star formation. It has high mass clusters and disperse populations.
- ~1° in molecular gas (~1° Mean in stars)
- Ages ~1 Myr (~10 Myr)
- ~20 pc away (only ~25% more than ONC)
- Very flat if at least better studied?
- Optical color gradient presence (~0.5-1.5 deg) and along a spiral arm. More sources in ~7 degree square here than in ~14 degree square in Taurus.
- Concentration is. problematic. Spitzer finds the stars AWS too late.
- Spitzer data have taken on ~200 previously known YSOs to ~2100 new YSOs in this region. Most of them are Class II, and about half are found within newly-defined clusters.


The “Gulf of Mexico”

The Gulf of Mexico can be seen as the dark dust lane above and in the 24.2 and 70 micron images in the lower left. “Optical” cluster A is on the northward and a few of these objects are seen in the optical and were identified in the literature, but the rest in the entire Gulf are new Spitzer discoveries. Some peculiar star groupings at 70 micron (~200 MIPS-24 sources) can be identified as part of the cluster, ~0.67 deg across, at ~60 pc ~75%, ~70% of the MIPS-24 sources have K counterparts (~90% of the MIPS-24 sources have K counterparts). The objects have a wide range of colors from photoplates to vary and (deeply embedded). The most embedded objects are more clustered. This is probably the youngest region of the NAN complex.

With SOFIA...

- Basic Science time using FORCAST at 24.2 and 3.45 mm; 2 pointings in the northernmost Gulf of Mexico (Fig A, ~3.1 deg and pig B+C, ~1.9 deg).
- 5rc A was observed using on-chip chopping & nodding, 5rc B+C was use off-chip chopping & nodding, to accommodate the extended emission; this method failed in flight.
- Multiple sources can be seen in pig A.

For the SEDs:
- ◆ = optical; ◆ = IRAC; ◆ = MIPS; ◆ = SOFIA; ◆ = limits

SOFIA is the longest wavelength detection of many of these objects! This will better enable characterization of the underlying objects in the youngest region of the NAN.