The Kleinmann-Low Nebula in Orion is the closest region of high-mass star formation. We present the first look at Orion-KL in the far-IR, using FIFI-LS onboard SOFIA. This has created a blister HII region bounded by the molecular cloud. Observations made during flights in 2014–2017. Observations of Orion-KL provide a prototype for more distant star forming regions.

The [CII] emission morphology and peak intensities (Fig. 1) highlight the overall shape of the blister region and specific PDRs of the Bar, near the Trapezium cluster, and complexes to the East of the BN protostar. These structures and brightnesses are consistent with previous velocity resolved Herschel observations (e.g., Goicoechea et al. 2015). The continuum emission (Fig. 2 contours) and the [CII] emission are correlated, but there is variation in the [CII] to continuum ratio as the [CII] traces the cloud blister surface while the continuum traces the dense line of sight material. The [OII] emission (Fig. 2 colorscale) shows a very similar pattern, which is likely a mixture of PDR emission as well as emission from the inner surface of the molecular cloud. Although the [CII] emission near the peaks is slightly optical thick, the [OII] is not (e.g., Goicoechea et al. 2015).

The [OIII] lines well trace the ionized component of the PDRs, and the S2 and 88 µm line ratio can be used to infer the electron density (e.g., Vacca et al. 1996). Fig. 3 shows the emission from the two lines with contours giving the derived electron density (log scale). The regions of highest electron density are around BN and near the Trapezium, slightly decreasing toward the Bar in the south. This is consistent with the blister morphology and the previous observations of the edge-on bar (e.g., Bernard-Salas et al. 2012). The higher-J CO lines were only detected around BN (Fig. 4). The observations are consistent with previous observations from PACS (e.g., Goicoechea et al. 2015) with emission morphologies and intensities from multiple temperature distributions. With the possible exception of J=13-12, the CO lines are strongest in the northeast and/or southeast, which coincide with the two peaks seen in the outflow HD (Johnstone & Bally 1999) from an explosive event ~1,000 years ago (e.g., Bally & Zinnecker 2005). Hot shocked CO gas is unusual in star forming regions, thus the gas seen here is likely to be from this event.

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The [OII] 52/88 µm line ratio maps the electron densities that peak around BN and near the Trapezium clusters. Ratios show the derived electron density assuming 10,000K (logn_e in cm^-3). Below: the ratio of the line intensities can be translated into an electron density mostly independent of electron temperature blue: 5,000K, black: 10,000K, red: 15,000K.

Conclusions

- FIFI-LS observations of Orion provide insight into the Orion blister nebula using simultaneous 2-channel FIR spectral observations
- The Trapezium stellar ionization is well mapped by the [CII] and the [OII] 146 µm emission lines.
- The [OII] 52/88 µm line ratio maps the electron densities that peak around BN and Trapezium, decreasing quickly to the East and more slowly toward the Bar. This morphology correlates with the dust continuum peaks indicating material being ablated from the denser regions.
- The high-J CO emission is consistent with multiple high temperatures related to HD outflows associated with a violent outburst about 1,000 years ago, which may make Orion a less than ideal archetype for more distant star formation regions.