Investigating the Properties of the Interstellar Medium Near Massive Star Forming Regions

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Abstract

We are conducting a survey of several regions of high-mass star formation to assess their content and structure (Allen et al. 2005). The observations include Spitzer observations, ground-based optical and near-IR imaging surveys, and optical and IR spectra of objects and locations in the molecular clouds. The goal of the survey is to gain a better understanding of the processes involved in high mass star formation by determining the characteristics of the stars detected in these regions, and investigating the properties of the interstellar medium (ISM) environment in which these stars form. The ISM in massive star forming regions contains different dust populations and states of gas (molecular, neutral, and ionized).

We present IRS spectra of several locations in the molecular cloud surrounding AFGL 4029. Strong emission from the PAH bands at 6.2, 7.7, 8.6, and 11.3 μm is detected at all locations, as well as emission from [Ne II] at 12.8 μm. The spectra are being utilized to investigate the chemistry and evolution of the H II and photodissociation regions in the cloud, and in particular to study the photochemical evolution of macromolecules and carbonaceous grains.

PDR Program

We have a survey in process of several regions of high-mass star formation using IRAC to assess their content and structure. The table at right shows the star forming regions in our sample. In addition to the IRAC imaging, we have obtained ground-based imaging at optical and near-IR wavelengths, and optical spectroscopy of selected stars in the regions (Allen et al. 2005, Chavarria et al. 2005).

Target	D (kpc)	IRAC area
NGC 7538	2.8	15'×20'
S88	2.5	15'×15'
S252	2.2	30'×30'
AFGL 437	2.0	20'×20'
S235	1.8	20'×25'
AFGL 4029	2.2	20'×30'
S255	2.4	20'×15'
S87	2.1	15'×15'
S76	2.1	15'×20'

AFGL 4029

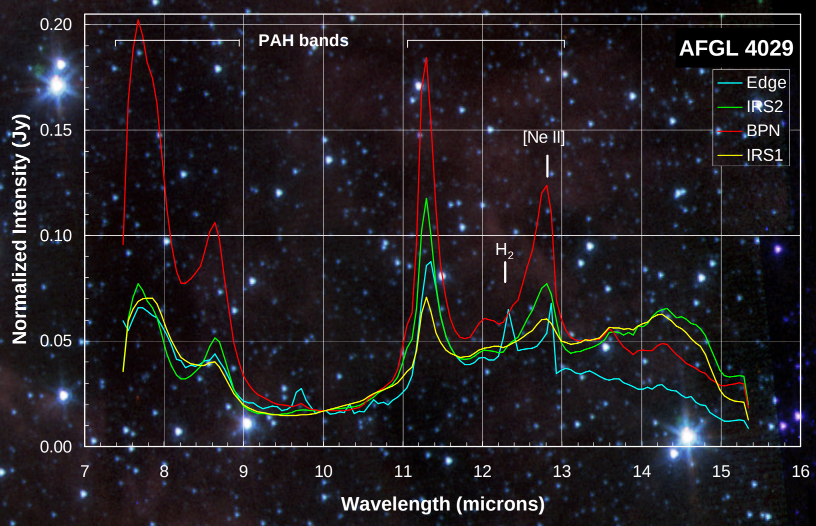
The IR source AFGL 4029 and associated molecular cloud is located 2.2 kpc in the Perseus arm of the Galaxy, and is part of the W5 complex of molecular clouds. The AFGL source consists of a pair of bright mid-IR sources (IRS1 on the west and IRS2 on the east) located near a photodissociation region (PDR) or "bright-rimmed cloud" at the edge of a bubble evacuated by an O star. Deharveng et al. (1997) observed the region near the sources in the optical and near-IR and found a young stellar cluster surrounding the mid-IR sources. They determined that one of the sources is a high luminosity young stellar object (YSO) with a strong ionized wind. The second source consisting of a compact H II region is less well understood. Zavagno et al. (1999) observed the mid-IR emission of the two compact sources and found IRS1 to be compact and consistent with a YSO and compact H II region excited by a B1 star. They found the 11.2 μm emission to be high in the arc-shaped nebula near the YSO. Ray et al. (1990) observed HH-like jets originating from the YSO.

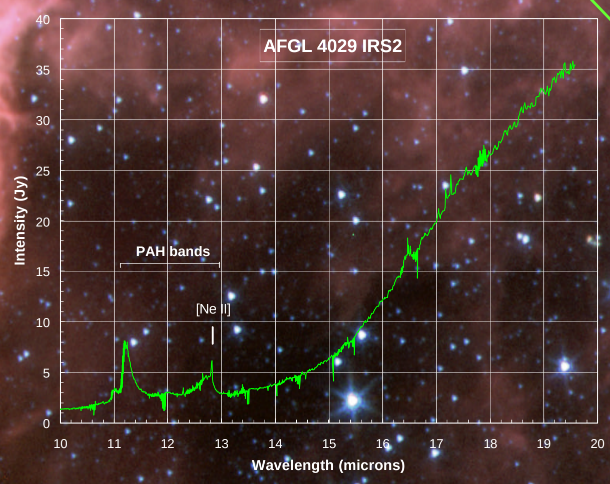
Preliminary Results:

We observed the region with Spitzer/IRAC, the 4 color image (Blue=3.6, Green=4.5, Orange=5.8, Red=8.0 μm), is shown as the background to this poster. The region near IRS1 and IRS2 is shown in the expanded region to the right, using a different scaling to allow the structure near the core to be seen. IRS1 is the bright pointlike source on the right, IRS2 is an extended nebula with several bright sources within or superposed on the source.

We obtained IRS spectra of several locations in the field, indicated by the rectangles superposed on the image below and below-right (IRS1 and IRS2 are the yellow and green rectangles). The data were reduced using the SMART analysis program. The 7-15 μm spectra from the short-low module of four locations are shown in the plot to the right. The 10-20 μm spectrum of IRS2 is shown in the plot below. The main features seen are the strong PAH bands at 7.7, 8.6, and 11.2 μm, with an emission "plateau" extending out to about 12.5 μm. The four spectra in the figure to the right are normalized to the "Edge" location at 10 μm. The PAH to continuum ratio varies the most for the location in the bipolar nebula, indicating different excitation conditions there. The ratio of the 7.7 /11.2 μm feature varies as well, with the 11.2 μm feature being relatively stronger in the IRS2 position compared to IRS1 or the other positions. Emission from [Ne II] at 12.8 μm is present at all locations as well. There is some evidence for H_2 ? = 0 – 0 S(2) at 12.3 μm at the "Edge" location, which may be excited by radiation incident on the surface of the cloud. The emission beyond 15 μm is dominated by a steeply rising continuum from cool dust.

Using photometry from the IRAC images, Allen et al. (2005) identified sources with IR-excesses and classified them into two categories: classical T-Tauri like star+disk systems, and protostellar star+envelope systems (see the Chavarria et al. poster, this conference; Allen et al. 2004, Megeath et al. 2004). The protostars are tightly clustered in two groups, one clearly on the edge of the cloud, coincident with the H II /molecular interface, and another slightly interior. The (presumably more evolved) T-Tauri stars are more widely dispersed, both inside the cloud and in the adjacent H II region.





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