CO ALONG THE LINE OF SIGHT TO GALACTIC CENTER INFRARED SOURCES

T. R. Geballe
Joint Astronomy Centre
665 Komohana Street
Hilo, Hawaii 96720
U. S. A.

ABSTRACT. High resolution spectra of the 4.64 micron 1-0 R2 line of CO toward infrared sources in the galactic center reveal absorption components identified with features in radio and millimeter wave spectra of molecular lines. They demonstrate that the +20 km/s cloud is situated in front of the Sgr A West and the +50 km/s cloud is behind it. The spectra of IRS 3 and IRS 7 have strong absorptions near +50 km/s, which may originate in the 2 pc radius circumnuclear ring; if so then the western side of the ring lies in front of the galactic center. A less likely interpretation is that these objects, which are only a few arc-seconds from IRS 16, are behind the +50 km/s cloud and, thus, well behind the galactic center.

1. INTRODUCTION

It is well known that the galactic center is obscured by ~ 30 mag of visual extinction. The extinction is contributed by a variety of objects: local clouds, the diffuse interstellar medium, spiral arms, expanding "features", rotating rings, and some anomalous clouds very close to the center. From observations at radio and millimeter wavelengths substantial information is available about these various gas concentrations. However, some rather basic controversies still exist. One of the most basic of these concerns the locations - in front of or behind Sgr A West - of the anomalous clouds which are generally known as the +20 and +50 km/s clouds.

An unrelated, but somewhat similar controversy has concerned infrared astronomers for some time. Many of the infrared sources close to the nuclear source, IRS 16, are easy to identify as belonging to Sgr A West; they (e.g., IRS 1 and IRS 2) are essentially clumps of ionized gas and associated dust. However, other sources, perhaps most notably IRS 7 and IRS 3, are different types of objects (Becklin et al. 1978), not directly associated with the ionized gas. IRS 7 is a luminous red supergiant, whereas IRS 3 is believed to be a dense circumstellar cloud associated with either a very young or a late-type star. Because these objects are not components of Sgr A West, their memberships in the cluster of objects in the central parsec of the galaxy have been questioned.

M. Morris (ed.), The Center of the Galaxy, 469–471.

One way of addressing both of the above controversies is to obtain spectra of absorption lines toward infrared sources that are located along the line of sight to the galactic center. Obviously, the presence or lack of absorption features can be used to determine the relative locations of clouds along the line of sight. Similarly, one might test the membership of the infrared sources in central cluster, by determining whether all of them display the same absorption profile.

The experiment summarized here attempted to answer the above questions by examining the velocity profile of the CO 1-0 R2 line near 4.64 microns. Spectra of this line towards a number of galactic center objects were obtained in 1986 and 1987 at the United Kingdom 3.8 meter infrared telescope, at resolutions of 40 and 20 km/s, using the facility cooled grating spectrometer and Fabry-Perot interferometers. Further details of the experiment and additional results are found in Geballe, Baas, and Wade (1988).

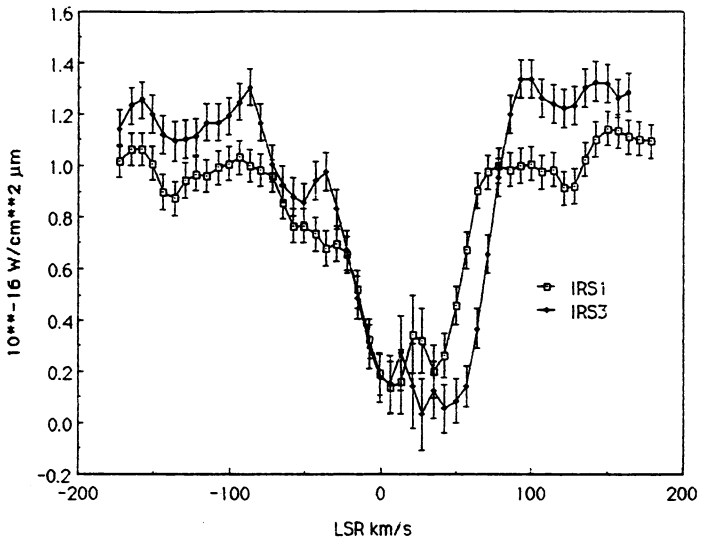

Fig. 1 - Spectra of the CO 1-0 R2 line, at 20 km/s resolution, toward the galactic center sources IRS 1 and IRS 3

2. RESULTS

Figure 1 shows spectra of IRS 1 and IRS 3 in the CO R2 line. Velocity components in both spectra that can be clearly identified with already known features (e.g., Gusten and Downes 1981, Serabyn et al. 1986) are the weak absorption at -135 km/s (corresponding to expanding molecular ring at a radius of 250 pc), a shoulder at -50 km/s (the 3 kpc spiral arm), and the deep absorption from 0 to +30 km/s, due principally to local gas and to the +20 km/s cloud. However the two spectra differ in that there is additional material at velocities near + 50 km/s in

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front of IRS 3. A spectrum (not shown) of IRS 7 in the same line, corrected for absorption by its photospheric CO, is even more extreme than that of IRS 3, showing absorption extending to +70 km/s. The spectrum of IRS 2 (not shown), on the other hand, appears to be similar to IRS 1, with no absorption at +50 km/s.

3. DISCUSSION

All of the observed sources show strong absorption at +20 km/s, implying that the +20 km/s cloud lies in front Sgr A West and all of the infrared sources in the galactic center. The lack of absorption near +50 km/s toward IRS 1 and IRS 2 is a strong demonstration that the +50 km/s cloud is located behind Sgr A West, and therefore behind the center. One possible explanation for the additional absorption toward IRS 3 and IRS 7, at +50 km/s and beyond, is that these two objects are located behind the + 50 km/s cloud, which would imply that they are more distant than the galactic center, at least by a few parsecs. However, in view of their close angular proximity to IRS 16, such a large linear separation seems unlikely.

A more plausible explanation for the extra absorption is that IRS 3 and IRS 7 are behind the circumnuclear ring which orbits the galactic center at a radius of ~2 pc. The most detailed maps of the ring (e.g., Gusten et al. 1987), which is tilted out of the galactic plane by approximately 20 degrees, show that both infrared objects lie at the inner western edge of the ring, as viewed in HCN, and that the ring has radial velocities in the range 40-80 km/s close to these sources. Because the HCN emission is primarily a tracer of high density molecular gas, it is probable that somewhat lower density ring material of a substantial column density lies along the lines of sight in question. Note that if IRS3 and IRS 7 are within the galactic center, but behind the circumnuclear ring, then it can be concluded that the western half of the ring is in front of the galactic center and the eastern half behind it.

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