FABRY-PEROT IMAGES OF IONISED AND MOLECULAR HYDROGEN IN SGR A.

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ABSTRACT. Images of the central 36 arcseconds of the Galaxy in the Brackett gamma line of atomic hydrogen (2.17μm) at a spatial resolution of 0.6 arcsec and a velocity resolution of 110 km/sec were obtained using UKIRT. The velocity separation between adjacent frames is 55 km/sec; 17 different velocities channels were imaged. Several distinct kinematic components are evident within the clumpy distribution of the ionised gas. An image in the v=1-0 S(1) line of molecular hydrogen (2.12μm) clearly resolves the structure of the "molecular ring."

INTRODUCTION

The recent widespread availability of arrays sensitive to infrared radiation has resulted in many remarkable images of the Galactic Center. For example, in these proceedings are pictures with superb spatial resolution (Rieke et al.), and of a large area (Gatley et al.). With the addition of a Fabry-Perot etalon to an infrared camera, imaging spectroscopy is possible. Several imaging Fabry-Perot systems have been developed for use at optical wavelengths, and have been used with great success (Atherton et al. 1982; Bland and Tully 1988). This paper describes observations of the Br g (n=7 to 4) line of ionized hydrogen and of the v=1-0 S(1) line of molecular hydrogen near the Galactic Center, using a Fabry-Perot system with modest velocity resolution; this experiment is primarily a demonstration of the method, for in the near future such studies should improve dramatically in both sensitivity and resolution.

OBSERVATIONS

The observations were made at the United Kingdom Infrared Telescope (UKIRT) on Mauna Kea in 1987 July. An infrared camera with an SBRC 58x62 InSb array detector (IRCAM; McLean et al. 1987) was used; the pixels of the array subtended 0.6" on the sky, which slightly undersampled the 1" seeing. An ambient temperature Fabry-Perot

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etalon set the velocity resolution of the observations at 110 km/sec; cold 1% bandpass filters were used to isolate a single order of the Fabry-Perot.

During the Br g observations the camera field was centered on IRS 16; the Fabry-Perot was scanned so that the line was sampled every 55 km/sec from velocities of +440 km/sec to -440 km/sec. The integration time for the individual exposures was 300 seconds. Thus, a "data cube" of Br g measurements 17 velocity channels deep and 36" in spatial extent centered on IRS 16 was created.

The sky, dark current, and bias contributions in the data were removed by subtracting measurements of a sky region well off of the Galactic Center made subsequent to each line observation. The data were flat-fielded using sky flats made from data taken throughout the night. The filter response was removed by normalizing the individual velocity channels with the signal measured from IRS 7 and another late-type supergiant in the field-of-view; both stars were assumed to have no intrinsic Br g emission (an assumption validated in the case of IRS7 by the high-resolution spectrum of Hall, Kleinmann, and Scoville, 1982). A velocity channel 1000 km/sec from the line center was observed to aid in the continuum determination, although in practice a median of all the velocity channels served to establish the continuum contribution (see next section).

Previous studies of the v=1-0 S(1) emission from near the Galactic Center made with the very FP etalon used in this experiment have shown that the line is only barely resolved at this resolution (Gatley et al. 1986). We therefore simply tuned the etalon to the velocity of the emission from the brightest clumps in order to study the morphology of the excited molecular gas at high spatial resolution. At each position additional measurements were made at velocities well displaced from the line velocity, so as to provide accurate continuum subtraction; the off-velocity frames also served to remove the dark current, bias, and sky contribution.

We also present here a map of the molecular hydrogen emission with 6 arcsec spatial resolution made at the CTIO 4-m telescope using the facility infrared cooled grating spectrometer, made in 1987 May by Gatley and Frogel.

RESULTS

Molecular Hydrogen Emission.

Many studies have shown that the molecular gas around the Galactic Center is distributed in a clumpy ring (Güsten 1987, and references therein). The low spatial resolution (20 arcsec) observations made by Gatley et al. (1986) in the v=1-0 S(1) line show that the molecular hydrogen emission follows this general pattern. Figure 1 compares a map of the HCN emission (Güsten et al, 1987) with a map of the molecular hydrogen emission (made at CTIO); both maps have a resolution of 6 arcsec, which is sufficient to resolve the clumps. Although generally rather similar, the HCN and molecular hydrogen surface brightness maps differ in detail, perhaps because of density and excitation variations within the molecular ring.

Fabry-Perot observations were made of the two brightest clumps of molecular hydrogen emission. The effective resolution of the data was set by the seeing, and was 1" FWHM, as measured from the profiles of stars in the frames. These images are shown in Figure 2, where they are compared to the data from figure 1. Despite the large improvement in spatial resolution in these new images, the emission is not further resolved into smaller clumps; the brightest emission is extended along the locus of the ring. This morphological result is consistent with the model in which the molecular hydrogen in the ring is shocked by a wind from the nucleus (Gatley et al 1986).

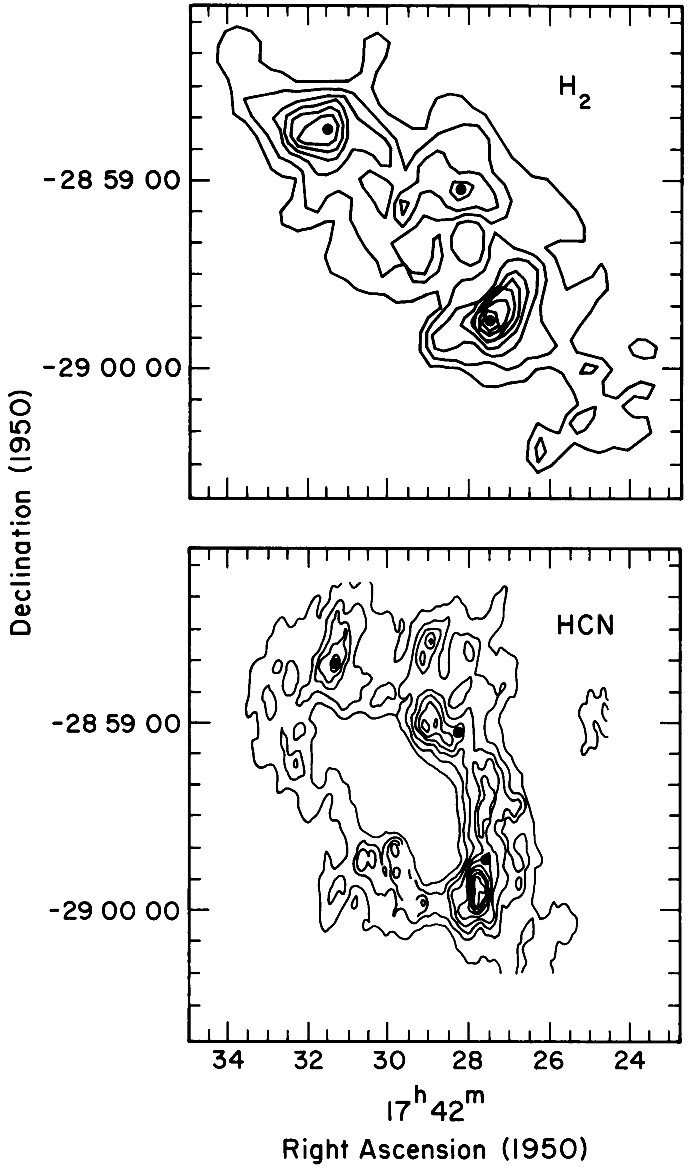

Figure 1.--A comparison of the v=1-0 S(1) molecular hydrogen line emission (mapped here at 6" resolution) with the HCN emission map of Güsten et al. (1987).

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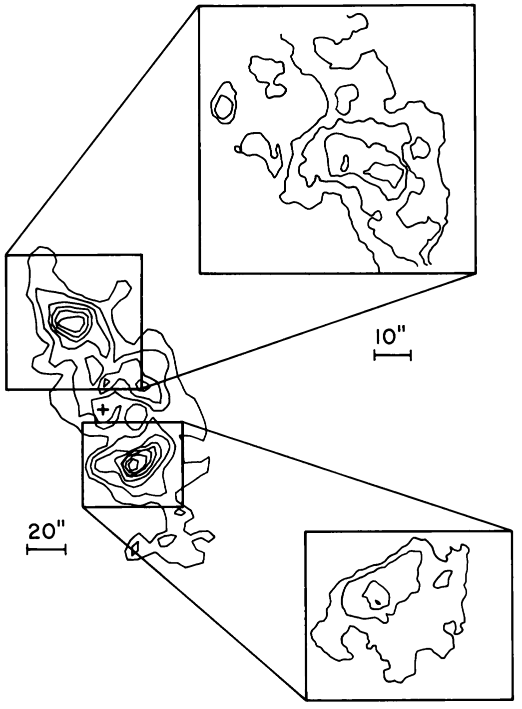

Figure 2.--Fabry-Perot images of the two brightest molecular hydrogen emission peaks; the larger scale map is that of Figure 1, and serves to indicate the position of the Fabry-Perot data.

Brackett Gamma Emission

The observations of the Br g emission in the Galactic Center imaged a 36 arcsec region centered on the nucleus. The 2µm continuum image of the observed region shown in Figure 3(a) provides a good perspective on the orientation and extent of the Br g data. This image was created by median averaging the entire Br g data cube in the velocity dimension; it is consistent with the frames taken of the region at velocities well away from the nominal line center. Well-known near infrared sources in the Galactic Center are easily distinguished in Figure 3(a); for example, IRS 7, IRS 16, and IRS 1 (Becklin and Neugebauer 1975) are all conspicuous. The spatial resolution of the image is also very good; the measured FWHM of several of the stars in the image is 1", sufficient to resolve IRS 16 into several components.

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The remaining frames of figure 3 show the data compacted into three velocity channels, each 250 km/sec wide. This form of presentation is forced upon us by limitations of space and medium here; at the meeting in Los Angeles, all of the individual velocity channels were displayed as a video in which successive frames scanned through velocity. That video displayed velocity structures not easily reproduced here.

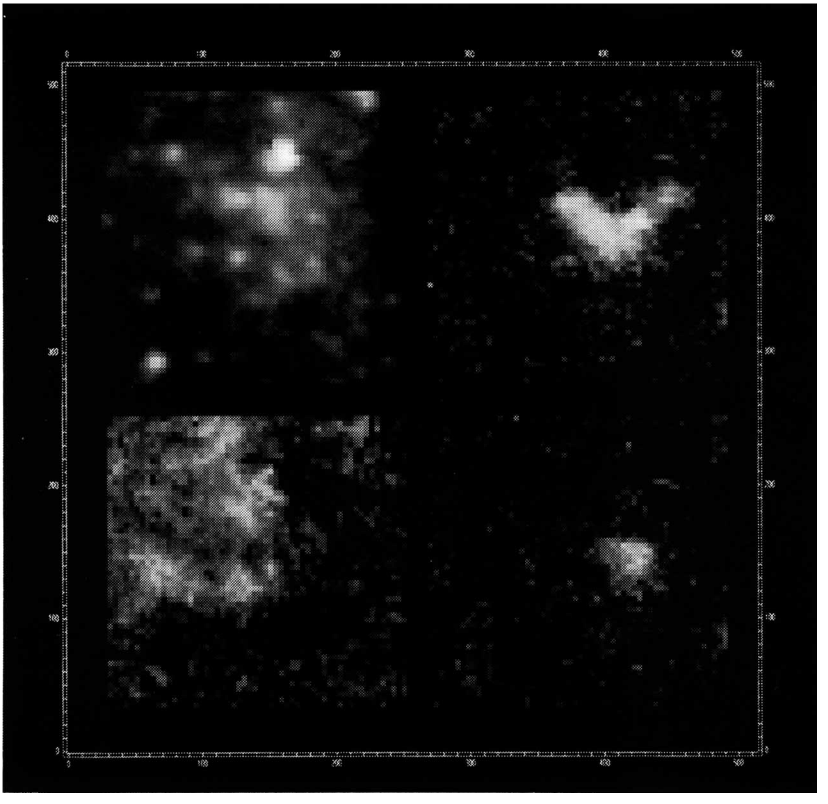

Figure 3(a)--The 2 µm continuum image of the Galactic Center (upper left).
Figure 3(b, c, d)--Images of the Galactic Center Br g emission compacted from the Fabry-Perot velocity channel data to an effective resolution of 250 km/sec. Lower right, lower left, and upper right frames are at blueshifted, redshifted, and stationary velocities respectively.

The Br g velocity field is, not surprisingly, very similar to the that deduced from the point-by-point measurements of [NeII] velocity profiles by Serabyn and Lacy (1985; see also Serabyn in these proceedings). In general, the velocity profiles measured in the brightest features of the 6 cm maps at [NeII] are well reproduced in the Fabry-Perot Br g data. A detailed comparison between the two data sets is difficult because of the lower resolution of the Br g data; in the future it will be straightforward to improve

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dramatically on the results presented here.
The integrated Br g emission image formed from the sum of all the line data (not shown here) closely resembles 6 cm radio continuum VLA maps (Lo 1987). The spatial resolution of the Br g image is somewhat lower than the radio maps, making the complex filamentary structure seen in radio maps difficult to detect. The faint emission seen here to the north-east of IRS 16 has also been detected in recent VLA observations (Ekers, these proceedings).

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