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60172

NASA
Ames Research Center

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Prep. by Witteborn
Page of

System Engineering Report

Sofia Scientific Advantages of 1 arcsecond
SUBJECT PROJECT

Spatial Resolution in the 2 to 8 micron range
DISTRIBUTION

(NASA-TM-110709) SOFIA SCIENTIFIC ADVANTAGES OF 1-ARCSECOND SPATIAL RESOLUTION IN THE 2 TO 8 MICRON RANGE (NASA. Ames Research Center) 11 p

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Response to SOFIA Action Item
from Fred Witteborn

SOFIA SCIENTIFIC ADVANTAGES OF 1 - ARCSECOND SPATIAL RESOLUTION IN THE 2 TO 8 MICRON RANGE

Calculations of the effect of the shear layer on image quality for a carefully designed SOFIA-type cavity show that image distortion may be less than 1 arcsec. in the wavelength range beyond about 2 microns. The diameter of an image enclosing 80% of a point source reaches 1.5 arcsec. at 8 microns, so the opportunity to benefit from images better than 1.5 arcsec. is confined to the 2 - 8 micron range. This is an important range for airborne astronomy because (1) much of it is hidden from groundbased observation by atmospheric absorption (primarily by H_2O and CO_2), (2) the reduction of background noise obtained by reducing optics temperatures to 240K is considerable in this spectral range, (3) a great deal of important astronomical information is accessible in this wavelength range (e.g. many molecular fundamental bands, solid state bands, the 3 micron cosmic window and penetration through dust surrounding star-forming regions.) Below we discuss briefly a few examples of the scientific benefits of 1 arcsec. resolution in the 2 - 8 micron range.

Star formation

Star formation is closely associated with HII regions which form around O and B stars imbedded in the clouds of molecules and dust that gave birth to them. VLA maps of 75 ultracompact HII regions were compiled with 0.4" resolution by Wood and Churchwell (1989). The use of subarcsecond resolution enabled them to show that the ultracompact objects had different morphologies not distinguishable by other means. Examples of well-known (the brightest) compact HII regions are shown in Fig. 1. It is evident that individual sources can be isolated on the scale of 1" so that spectroscopy of such sources would not confuse the physical/chemical characteristics of totally different sources. Since the closest region of O and B star formation is about 450 pc away, we cannot beat the scaling problem simply by looking at closer examples. Observations in the 2 - 8 micron range cover the fundamental vibration bands of H_2O, CO_2, CO, NH_3 and CH_4, all very important in star forming regions. In addition this range covers the major ice absorption bands near 3 and 6 microns which are studied not only because they reveal the presence of H_2O ice, but because the band shape reveals impurities and temperature history.

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Planet Formation

Beta Pictoris may present the closest example of planet formation in progress. Observations with 1" resolution could help to settle the extent to which the inner region (T>140K) is depleted of dust and gas. (One arcsecond corresponds to 16 AU at the distance of Beta Pictoris.) Some authors (e.g. Smith and Terrile, 1984) have suggested that the inner region is depleted because of planet formation. Another possibility is that the apparent depletion simply represents a phase transition, particularly since the "depleted" region lies where ice would sublime quickly(Backman, Gillett and Witteborn, 1990). Of particular interest would be a molecular emission spectrum of this region to show the gas content of the extended cloud and how its composition varied with distance from the central star.

Mars Surface Spectroscopy

Recent analysis of KAO spectra of Mars in the 5 - 10.5 micron range has provided information about carbonates, sulfates and other materials in the Martian atmosphere and surface (Roush, et al., 1989 and Pollack et al., 1989). These measurements provided crude spatial resolution of surface mineralogical distribution because the 7 arcsecond spread of KAO images averaged over the properties of many types of underlying surface features. At opposition, the Mars disk can be as large as 23 arcseconds diameter and as small as 14 arcseconds. During the better oppositions the largest volcanoes are then on the order of 1" in size and polar caps are somewhat larger, so that spectroscopy of a 1" feature can really isolate a characteristic mineralogy. Reflectance spectroscopy is a powerful tool for studying the surface mineralogy. The highest spatial resolution provides the greatest ability for geologic interpretation of the regional internal and surface processes which have been active throughout a planet's history. The 2 - 6 micron range is ideally suited for characterization of a variety of volatile-bearing minerals such as hydrates, hydroxides, water ice, CO_2 ice, carbonates, and sulfates.

Occultations of Stars by Planetary Atmospheres and Rings.

The thermal structure of a planetary atmosphere can be studied by measuring the time resolved brightness of a background star during an occultation (Elliot, 1979). Earth-based stellar occulations cover an altitude range in the gap extending above spacecraft radio occultations and below spacecraft UV stellar or solar occultations. A series of stellar occultations by a planetary ring system can provide exceedingly precise orbital data, leading

to an understanding of the age and evolution of the rings and to the internal structure of the planet through the harmonics of its gravitational field (French, et al., 1988). The quality of an occultation observation can be enhanced by working in a wavelength band where the planet is relatively dark and by minimizing the size of the stellar image. In the case of Saturn, 6.2 microns is an intensity minimum for both the disk and the rings. The contribution from rings and disk is half as large if 1" resolution is achieved than if 1.5" is achieved. Since the desired information comes only from the image of the star and noise is derived from both statistical fluctuations in the ring and disk as well as from guiding errors, it is crucial to make the non-stellar contribution to emission as small as possible. The ability to discriminate spatially between the rings and the disk is enhanced with the smaller stellar image size and this permits the choice of other absorption bands for monitoring the occultation.

References:

Backman, D. E., Gillett, F. C. and Witteborn, F. C., 1990 (submitted to Ap. J.)

Elliot, J. L., 1979, Ann. Rev. Astron. and Astrophys., p 445.

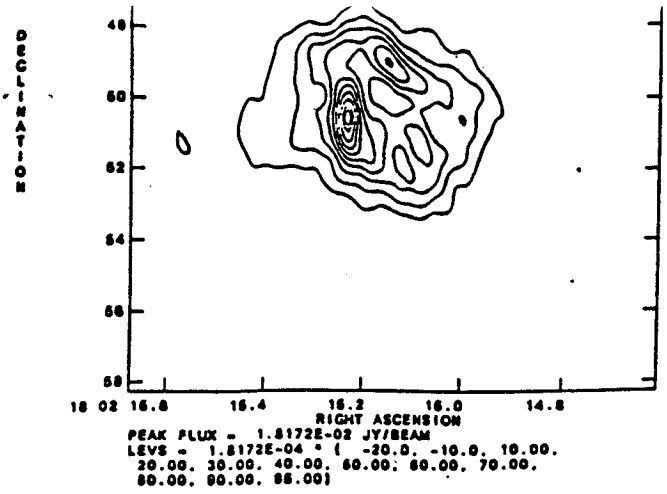
French, R. G., Elliot, J. L., French, L. M., Kangas, J. A., Meech, K. J., Ressler, M. E., Buie, M. W., Frogel, J. A., Holberg, Fuensalida, J. J., and Joy, M. ,1988, Icarus 73, p 349.

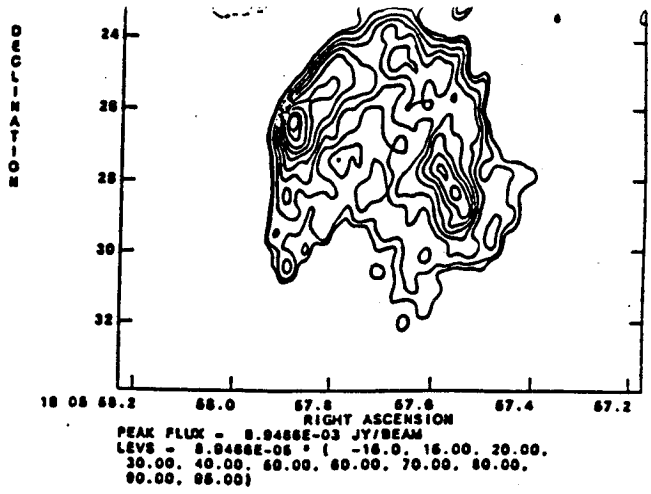
Pollack, J. B., Roush, T., Witteborn, F., Bregman, J., et al. (submitted to J. Geophys. Res.)

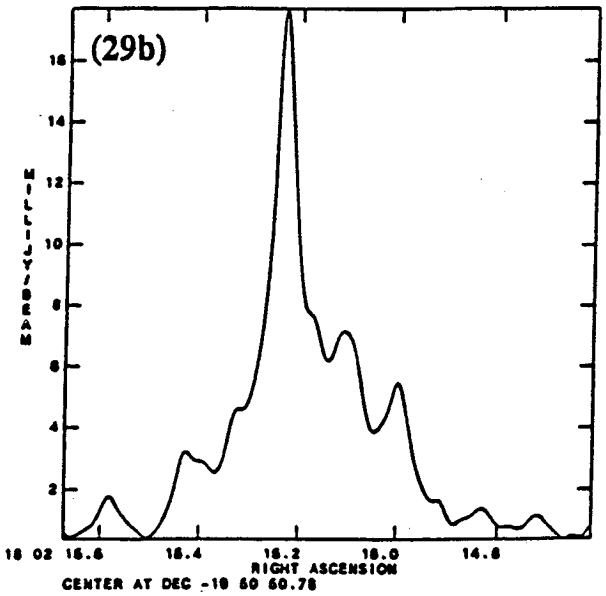
Roush, T. L., Pollack, J. B., Stoker, C., Witteborn, F., Bregman, J., Wooden, D., and Rank, D., 1989, Lunar and Planetary Science Conf. XX, Lunar and Planetary Science Institute, Houston, TX, p 928.

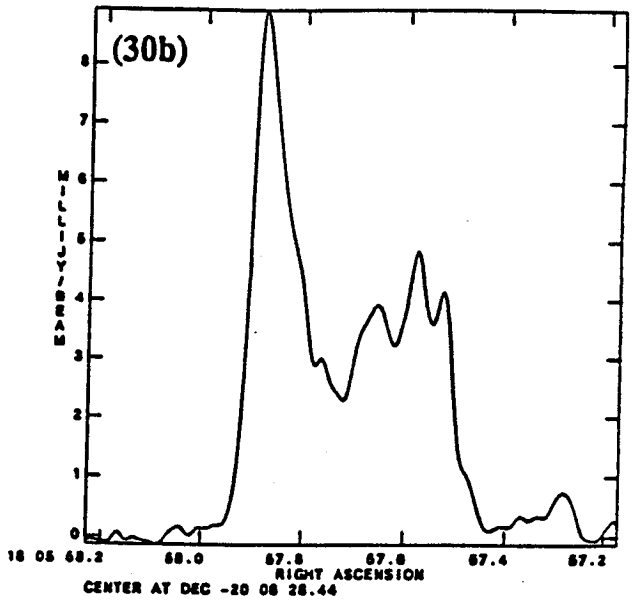
Smith, B. A. and Terrile, R. J., 1984, Science 226, p 1421.

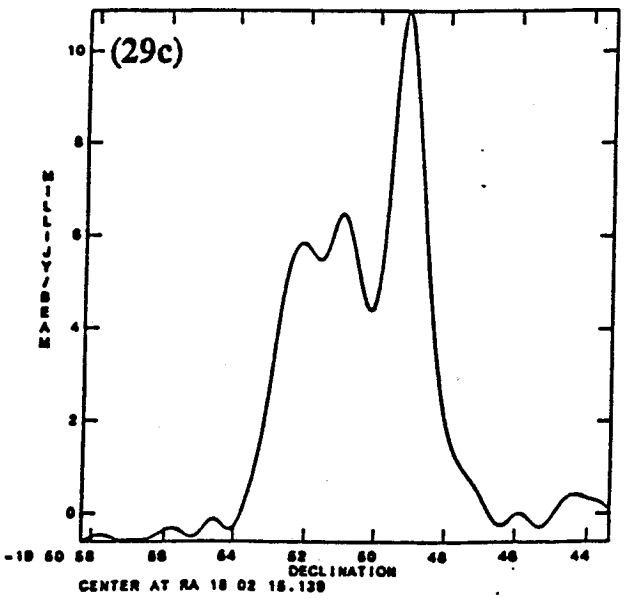
Wood, D. O. S. and Churchwell, E., 1989, Ap. J. Supp. 69: p 831.











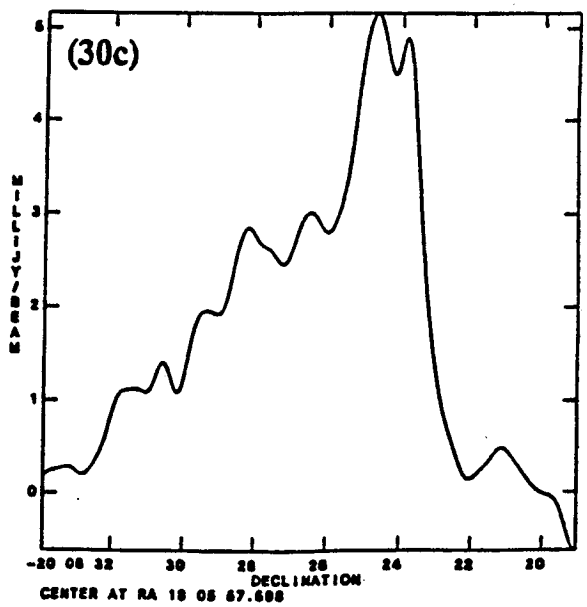


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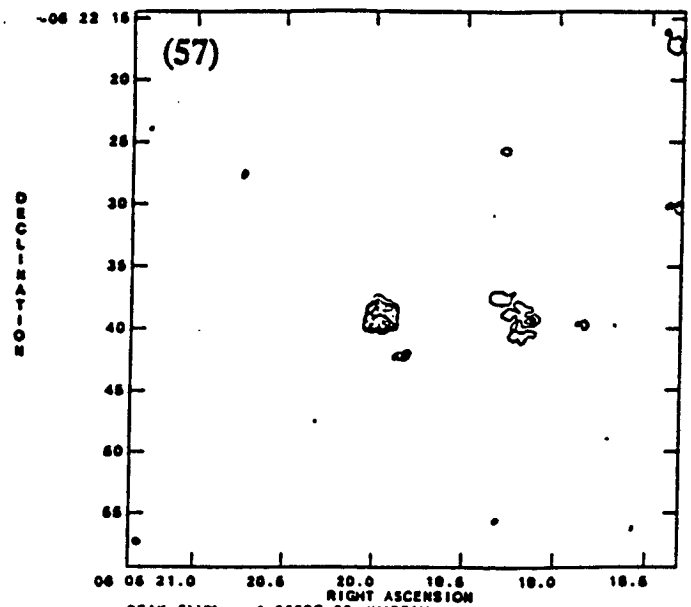
Fig. 14

MON R2 IRS1 — 2 CM



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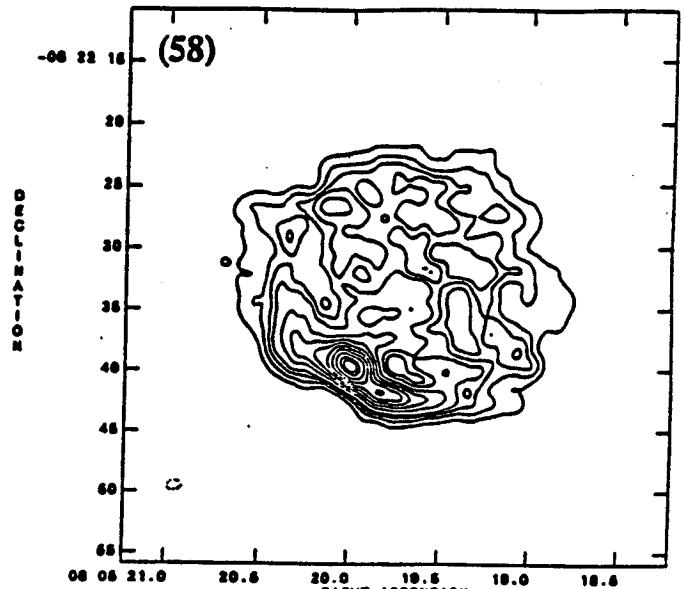

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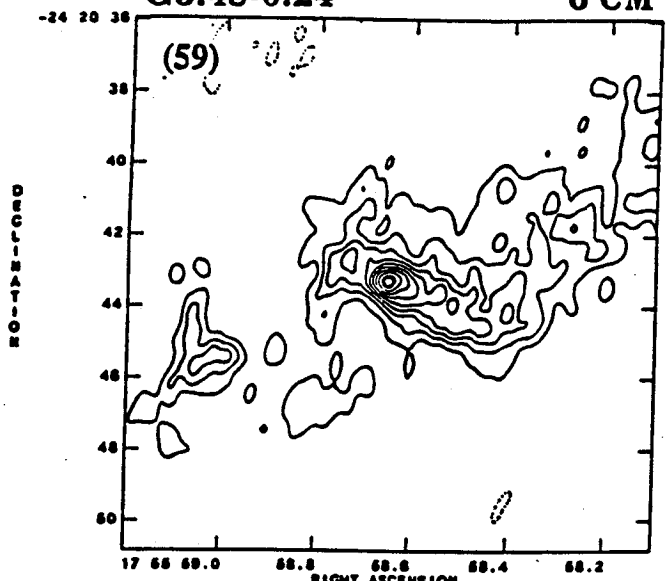

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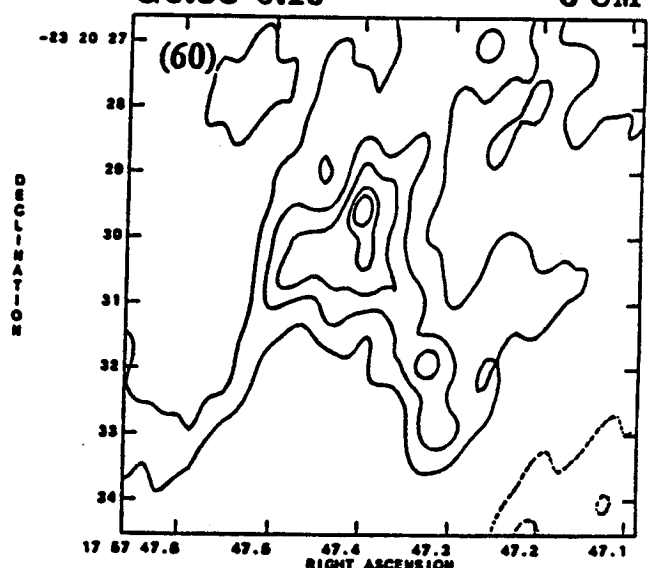

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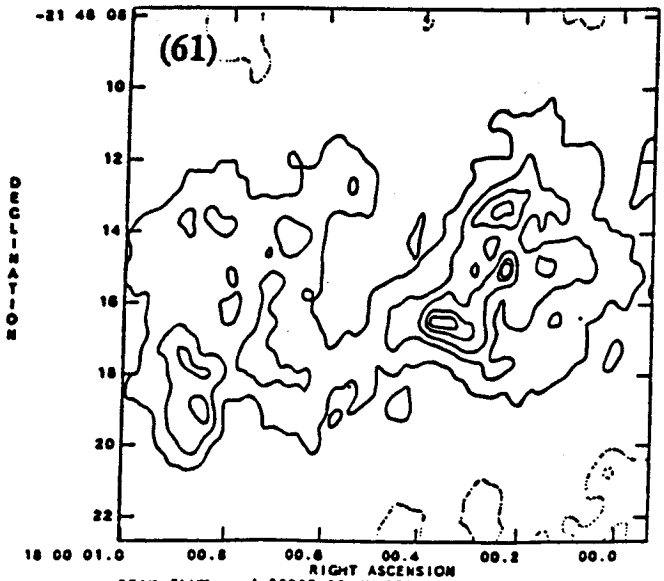

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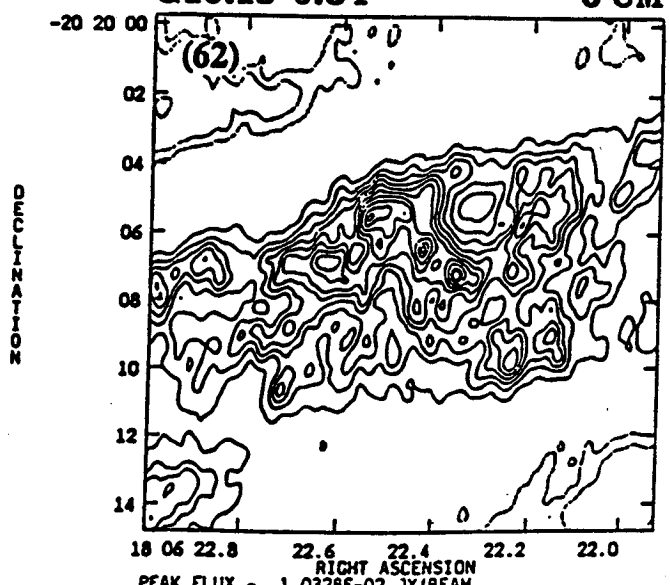

PEAK FLUX = 1.0328E-02 JY/BEAM
LEVS = 1.0328E-04 * (-20.0, -10.0, 10.00,

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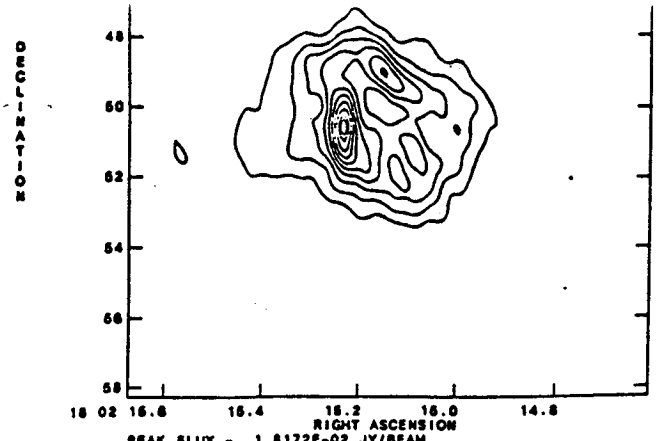

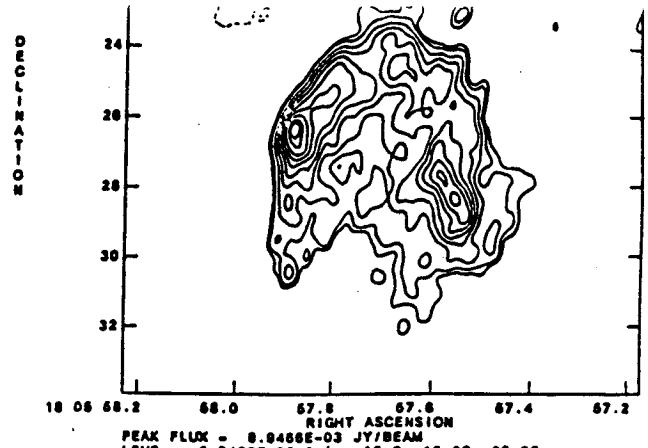

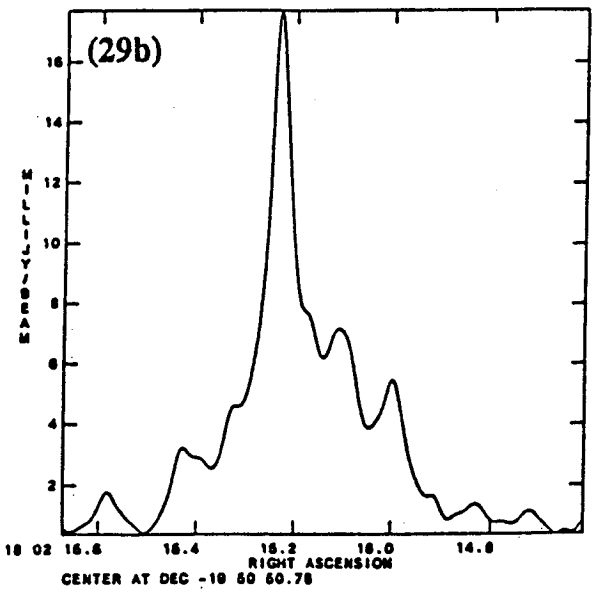

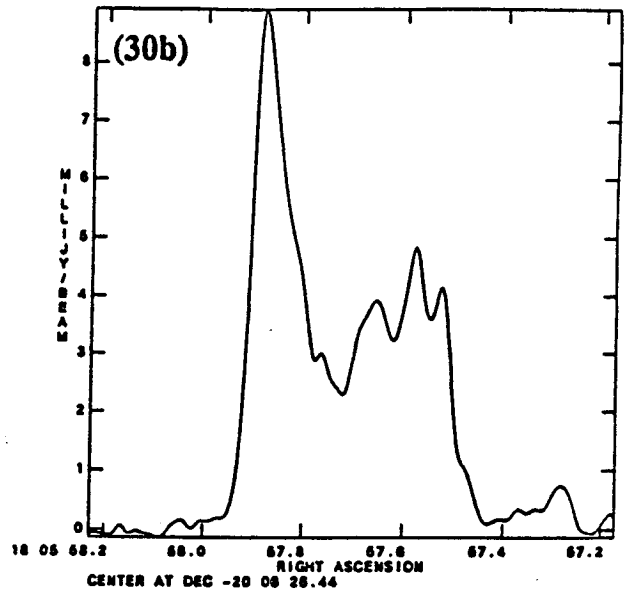

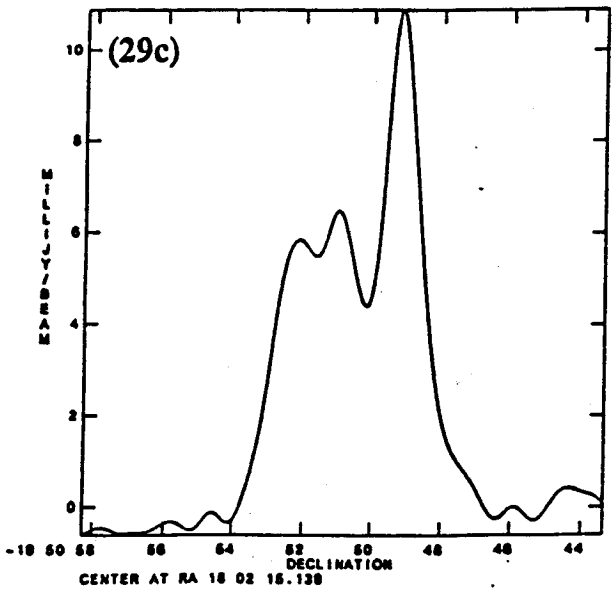

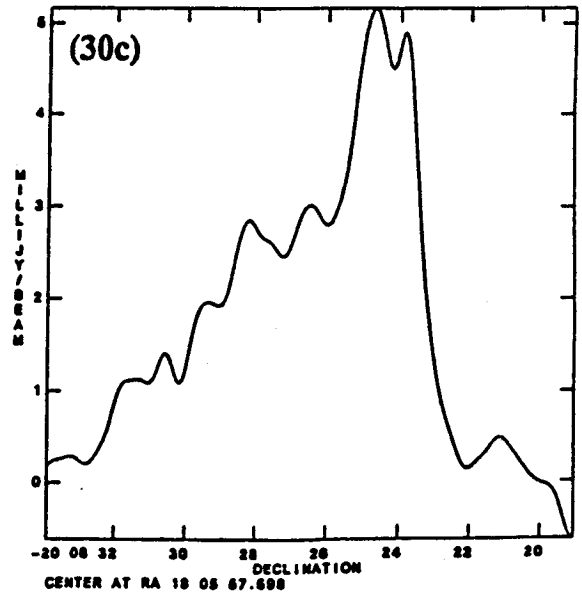

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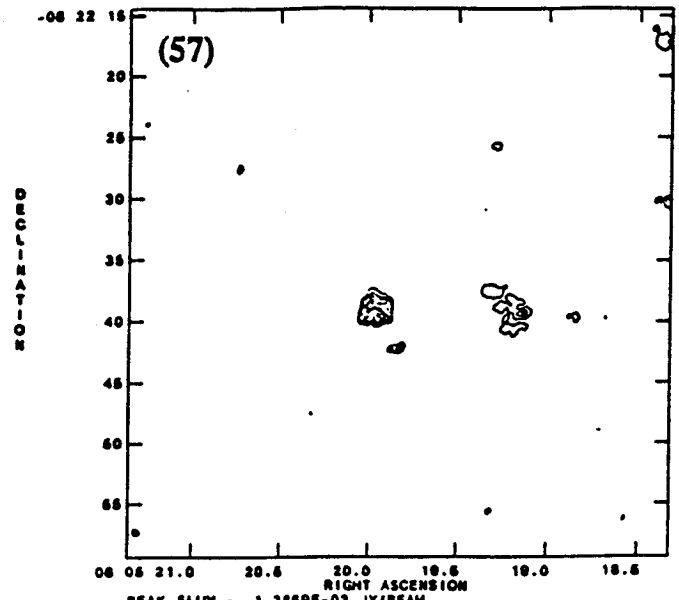
Fig. 19

MON R2 IRS1 2 CM



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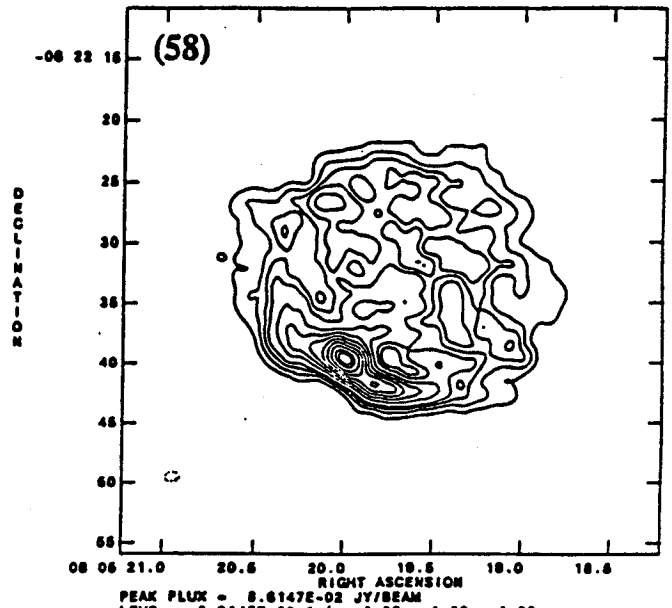
MON R2 IRS1 6 CM



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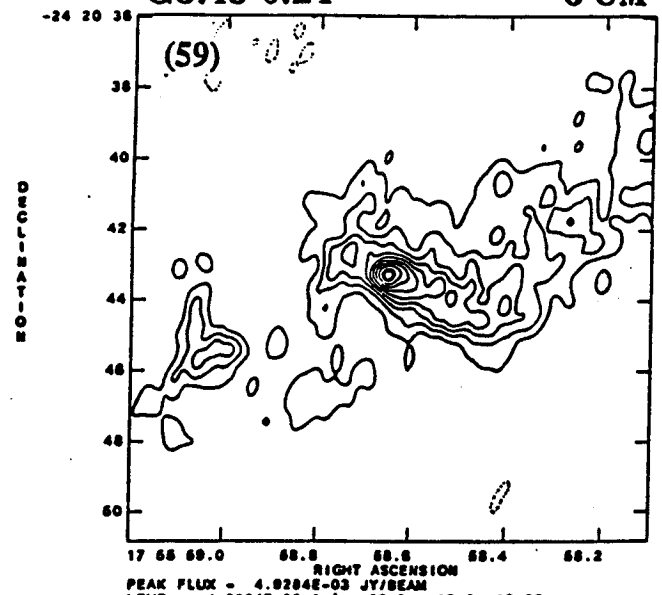
G5.48-0.24 6 CM



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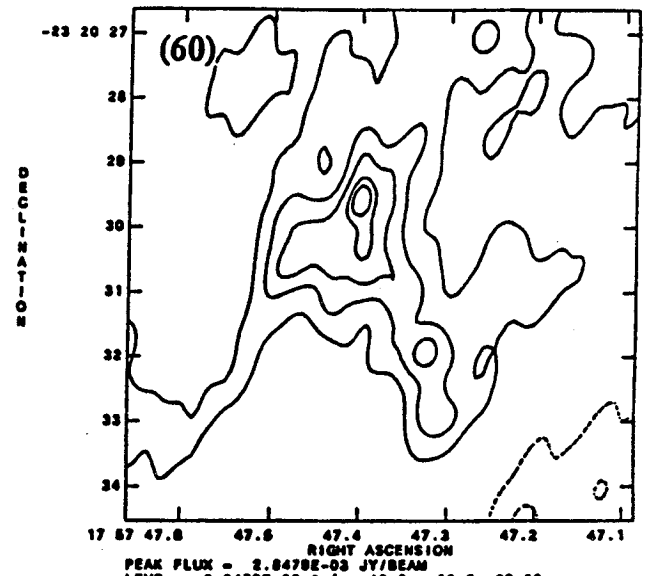
G6.55-0.10 6 CM



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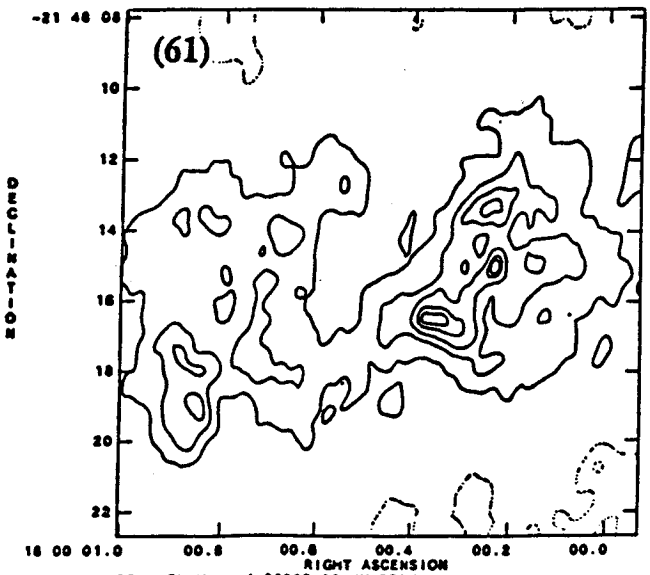
G8.14+0.23 6 CM



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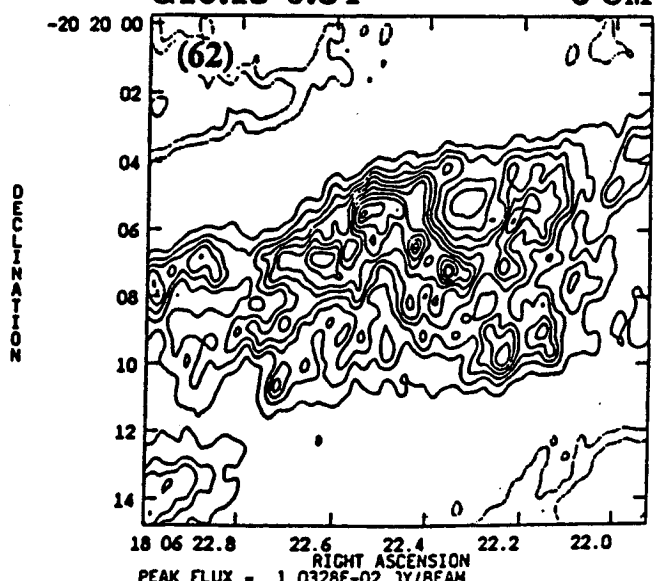

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