AN IR QUINTUPLET NEAR THE GALACTIC CENTER

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ABSTRACT. A cluster of luminous infrared sources has been found near the Galactic Center. It consists of five identical stars clustered in a compact volume, to be called an IR quintuplet. They are all highly reddened, strongly polarized and associated with deep absorptions of silicate band and CO vibration band. They seem to be a cluster of young stars newly born near the Galactic Center.

I. INTRODUCTION

The objects were discovered serendipitously in the polarimetric survey of the infrared sources in the Galactic Center region (Kobayashi et al 1980) as a pair of stars with large reddening and strong polarization.

After the discovery, a number of observations-photometric, spectroscopic and polarimetric- have been made to identify the nature of the sources (Okuda et al, 1986). They have been resolved into five sources by recent imaging with an IR camera (Nagata et al, 1988). The objects are very intriguing from their striking similarities in their characteristics and the proximity to the Galactic Center.

Here we summarize the observed results obtained so far & discuss the nature of the sources.

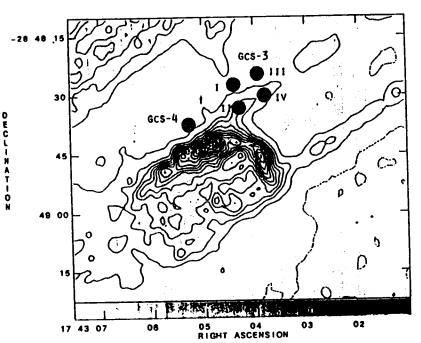

Fig. 1. Location of the quintuplet plotted on the VLA map of Yusef-Zadeh and Morris (1987)

M. Morris (ed.), The Center of the Galaxy, 281–285.

II. OBSERVED RESULTS

The positions of the sources observed by the IR camera coincide closely but not exactly, with a bright radio spot G0.15-0.05, which is called "Pistol" in the VLA map of the Radio Arc near the Galactic Center (Yusef-Zadeh et al (1987)). They are plotted on their map reproduced in Fig. 1.

All the five sources are strongly polarized (~ 5% at K-band), and their polarization vectors are nearly parallel to the galactic plane. The degrees of polarization decreases with wavelength in the same manner as seen in the interstellar polarization. The polarizations are very similar to the Galactic Center in degree and position angle, as illustrated in Fig. 2.

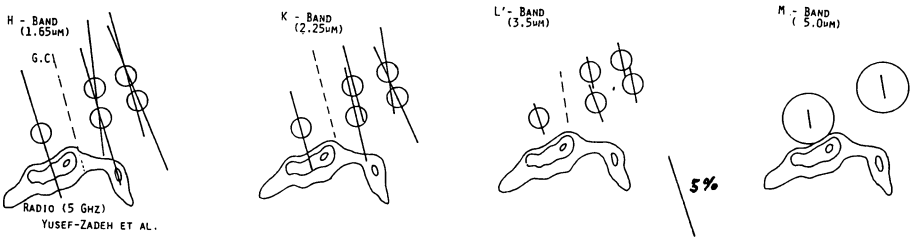

Fig. 2 Polarizations of the quintuplet

The energy spectra of the sources are also all similar, as shown in Fig. 3, with peaks near 5 μm and deep silicate absorptions at 10 μm. In near infrared spectra, there has been found no hydrogen recombination lines such as Bγ (2.17 μm), Bα (4.05 μm), no H_2 emission line(1-0, S(1)) at 2.12μm, nor absorption of CO vibration-band at 2.3 μm. Also no ice absorption is present at 3.0 μm, but a trace of depression is seen at 3.4 μm, which has been detected in IRS-7 and IRS-1 in the Galactic Center sources (Allen and Wickramashinghe, 1981).

Clear and deep CO absorption of fundamental series at 4.7 μm has been found in the recent spectroscopic observations by CGAS on IRTF (Nagata et al 1988). A typical example of the observed spectra is shown in Fig. 4, where rotation band structures are clearly seen for both R-and P-branches. The equivalent widths of the absorption bands decrease rapidly with J-value.

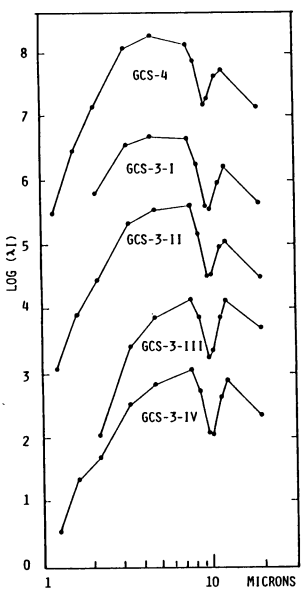

Fig. 3 Energy spectra of the quintuplet

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The spectral profiles of all the other sources are indistinguishably identical.

Detailed line profiles of individual rotation lines were measured by the Fabry-Perot spectrometer on UKIRT (Nakagawa et al 1988). The observed profiles show strong absorption at negative velocities (-50km/s, -75km/s), as well as shallower absorption around 0-40 km/s. (Fig. 5).

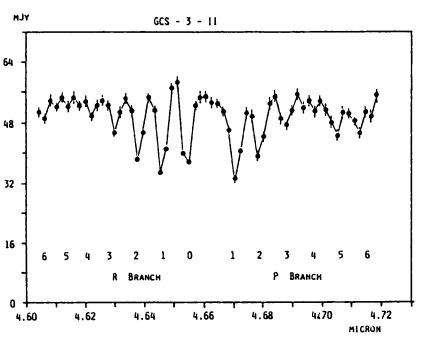
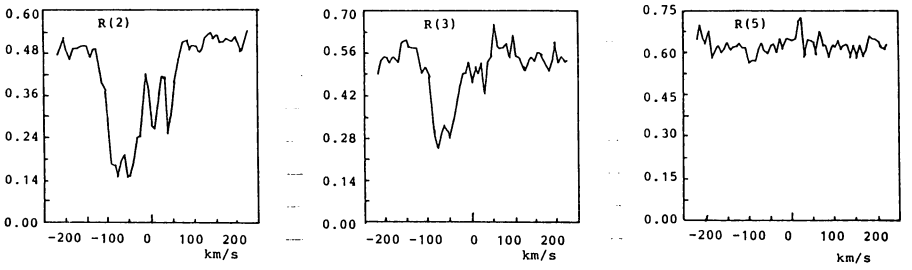


Fig. 4 Fundamantal vibration-rotation band observed in GCS-3 II

Fig. 5 Velocity resolved spectra of vibration-rotation band observed in GCS-3 II



III. DISCUSSION

All the features so far observed may not be intrinsic to the sources because of their remarkable similarity, but they can be mostly explained in terms of an interstellar origin.

The silicate absorptions at 10μm and the polarizations in near infrared region are well understood as caused by interstellar extinction. The optical depths of the silicate bands and the polarization degrees are comparable to those observed for the Galactic Center sources (Kobayashi et al 1980, 1983, Lebofsky et al 1982). This indicates that the sources are located near the Galactic Center.

If that is the case, the intrinsic luminosities of the sources range from 10^4 to 10^5 $L_\odot$, corresponding to those of bright giant or supergiant stars. It is a little controversial, however, that they do not show any characteristics typical for either early or late type giants / supergiants, i.e., $B\alpha$, $B\gamma$ emission lines or CO overtone absorption band at 2.3μm are absent. Non association of high temperature stars is indicated from the absence of radio continuum emission. The closeness to

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the compact radio source "Pistol" is interesting but the observed displacement of positions are evidently exceeds the observational errors.

The intrinsic energy spectra, after correction for interstellar extinction assuming the distance of the Galactic Center, show a smooth and featureless blackbody-like spectrum with temperatures ranging from 600K to 900K. They resemble the spectrum of extremely reddened stars with thick circumstellar dust layer such as OH/IR stars, but no corresponding radio emission has been found.

Although we have no positive evidence to identify them as a special type of object, the following argument may be interesting to be added.

The sources are clustered in a very compact region, within 1pc even if they are located at the Galactic Center. If they were evolved objects, they should have spread out due to a dispersion in their proper motions.

The remarkable similarities in their characteristics also suggest their youth, for small differences in the initial conditions at the time of birth would have resulted in large differences in their behaviors if they had undergone a long evolutionary process.

These arguments would indicate that the sources are really young objects to be called "a quintuplet", which have been recently born near the Galactic Center.

Finally, we would like to add a few comments on the CO-absorption.

From the variation of the optical depth of rotation bands, we can estimate the population of rotation levels at different J-values, from which the rotation temperature is inferred under the LTE assumption. The temperature of CO-molecules is thus estimated to be as low as 10K. This is the typical temperature of CO-molecules in general interstellar medium deduced from radio observations.

Once the excitation temperature is determined, the column density of the responsible molecular clouds is estimated unambiguously;

$N(CO) = 10^{18}/cm^2$, which corresponds to
$N(H_2) = 1.6 \times 10^{22}/cm$, if we assume a CO/H radio of 6×10^{-5}.

This is smaller than the value generally adopted for the total hydrogen column density between the Galactic Center and the Sun; $N(H) = 5\text{-}6 \times 10^{22}/cm^2$ estimated from the total interstellar extinction of Av= 25-30 mag. The difference may be attributed to the contribution of HI clouds.

The dominance of the negative velocity component in the absorption spectrum contrasts with the positive velocity components predominant in the radio CO observations. (Bania 1986, Bally et al 1987,). The velocity profile is drastically changed from that observed in the Galactic center sources where positive velocity components dominate (Geballe, 1988).

Since negative velocity is forbidden in the sense of galactic rotation in this direction, that may correspond to the expanding motion of the 3 kpc arm (-50 km/s) and the Galactic Center molecular ring (-150 km/s).

Detailed discussion of the implication of the CO absorption will be given elsewhere (Nakagawa et al 1988).

Although the CO absorptions could not provide a decisive clue on the nature of the quintuplets, it has opened a new and useful aspect for studies of CO molecular clouds in interstellar space(Geballe 1988).

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