62. Possible Presence of HCN in HD182040

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It has been suggested by Tsuji (1964) from an extensive study of dissociative equilibrium that some polyatomic molecules may be present in the atmospheres of cool stars. Quercis (1970) have shown the possibility of CH_2 in UU Aur (C5,3**) in the photographic infrared region. Hirai (1974a) suggested the presence of C_2H_2 in U Hya (C7,3) in one micron region and also $\lambda 7887$ band of C_2H_2 in 19 Psc (C6,2) and Y CVn (C5,4) (1974b). Giguere (1973) made one micron research for HCN in 19 Psc and UU Aur.

These researches, however, have not yet reached to the definitive conclusion and it seems that further study should be necessarily done. Keeping such a situation in mind, I will discuss the possible presence of HCN in carbon stars from the investigation of the photographic infrared spectral region of these stars.

The HCN molecule has some band sequences (e.g. $4\nu_3$, $3\nu_1+2\nu_3$, $\nu_2+4\nu_3-\nu_2$) in the spectral range from around $\lambda 7800$ to $\lambda 8000$, the laboratory investigations of which have been carried out by Herzberg and Spinks (1934), Douglas and Sharma (1953) and Rank *et al.* (1960). The characteristic feature of the spectra of carbon stars in the spectral region considered is composed mainly of CN Red System (2,0), (8,5) and (7,4) sequences (Davis and Phillips 1963), some C_2 lines, and few atmospheric H_2O lines. Further in some carbon stars, isotopic C^{13}N lines are fairly strong and they make the identification of each line very difficult.

In the present study observational data have been obtained in 1974 at the Palomar Observatory by using coudé ITT image tube at the 72 inch camera of the 200 inch telescope arranged and carefully tested by Professors Greenstein and Münch. Each spectrogram of carbon stars 90 mm wide obtained gives a dispersion of $6.7 \text{ \AA mm}^{-1}$ and its spectral range covers $\lambda 7670$ through $\lambda 8640$. These spectrograms have been traced by the microphotometer of the Department of Astronomy, University of Tokyo.

Some details of the identification of absorption lines of five

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^{**) Spectral types indicated here are all due to KM classification (Keenan and Morgan 1941) except for ST Cas (Yamashita 1972).}

spectral regions $\lambda 7898\sim 7900$, $7901\sim 7906$, $7913\sim 7916$, $7920\sim 7924$, and $7988\sim 7992$ are listed in Table I and the location of each line is graphically illustrated in Fig. 1. It should be noticed from Fig. 1 that the situation of searching HCN becomes more favourable when the $C^{13}N$ isotopic lines are either very weak or absent. As two illustrations with asterisks will show, two HCN lines $4\nu_3$ P(5) and $3\nu_1+2\nu_3$ P(11) in the spectral region from $\lambda 7921$ to $\lambda 7923$ and one HCN line $\nu_2+4\nu_3-\nu_2$ P(13) in the spectral region from $\lambda 7984$ to $\lambda 7991$ are isolated from other contributors, particularly in the former case.

Investigation of spectrograms described above for determining the C^{12}/C^{13} abundance ratio of carbon stars (Fujita and Tsuji 1976) has revealed in three carbon stars RX Peg (C5,5), ST Cas (C4,4), and HD182040 (C1,2) that the estimated value of C^{12}/C^{13} ranges from around 6 to $>10^2$. Fig. 2 shows the microphotometric tracing of these three carbon stars in the spectral range from $\lambda 7917$ to $\lambda 7929$.

It should be noticed in Fig. 2 that a feature around $\lambda 7921$ is very pronounced in HD182040 and no such feature is seen in other

Fig. 1. Schematic representation of the spectral feature in five photographic infrared regions of carbon stars.

Fig. 2. Microphotometric tracings of the spectral region from $\lambda 7917$ to $\lambda 7928$ of three carbon stars RX Peg, ST Cas, and HD 182040.

two stars. As was remarked already HD182040 shows very weak isotopic $C^{13}N$ lines. Therefore this feature is quite possible to be identified as blended $7921.62\ 4\nu_3\ P(5)$ and $7921.83\ 3\nu_1 + 2\nu_3\ P(11)$ lines of HCN. For other three regions (without asterisk in Fig. 1) the situation is not so favourable for identifying HCN lines.

It is my great privilege to express my hearty thanks to Professor J. L. Greenstein and Professor G. Münch for setting coudé ITT image tube at the 72 inch camera of the 200 inch telescope in use and particularly to the former who kindly helped me a great deal for testing this special arrangement before observation.

The author is grateful to Dr. T. Tsuji for tracing all the spectrograms by the microphotometer above described and for useful discussions. Thanks are also due to Miss K. Uzawa for preparing the manuscript.

Table I

λ	Identification	λ	Identification
7898.11	CN(2,0)R ₁ (14)	7915.70	CN(2,0)P ₁ (3)
98.38	CN(2,0)Q ₂ (10), C ₂	7920.02	C ¹³ N(2,0)R ₂ (10)
98.49	CN(2,0)P ₂ (6)	20.06	CN(2,0)Q ₁ (22)
98.53	C ¹³ N(2,0)R _{2,1} (8)	20.23	CN(2,0)Q ₁ (11)
98.99	HCN 4v ₃ R(7)	20.67	Atm H ₂ O
99.49	CN(2,0)R ₁ (3)	20.78	CN(2,0)P _{1,2} (3)P ₁ (5)
99.83	CN(2,0)R ₁ (15)	20.83	C ₂
99.92	C ₂	21.13	C ¹³ N(2,0)Q ₂ (1), C ₂
99.94	C ¹³ N(2,0)R _{2,1} (7)	21.32	C ¹³ N(2,0)R ₂ (11)
7901.85	CN(2,0)Q ₂ (11)R ₁ (16)	21.62	HCN 4v ₃ P(5)
03.23	CN(2,0)P ₂ (7)P _{1,2} (10)	21.83	HCN 3v ₁ +2v ₃ P(11)
03.39	C ¹³ N(2,0)R _{2,1} (5)	22.46	C ₂
03.89	CN(2,0)R ₁ (1)	22.58	C ¹³ N(2,0)Q ₂ (2)
04.14	CN(2,0)R ₁ (17)	22.73	CN(2,0)R ₂ (25), (8,5)Q ₂ (24), (7,4)P ₂ (38)
04.55	CN(2,0)R ₂ (21)	22.91	C ¹³ N(2,0)R ₂ (12)
04.56	CN(8,5)R ₂ (29)	22.94	CN(2,0)Q ₂ (16)
04.95	HCN 4v ₃ R(3)	23.76	HCN 4v ₃ P(6)
05.44	C ¹³ N(2,0)R _{2,1} (4)	23.80	CN(2,0)P ₁ (6)
05.57	C ₂	7988.11	Atm H ₂ O
05.59	CN(2,0)Q ₂ (12)	88.47	C ₂
05.75	Bal0	88.95	CN(8,5)P ₂ (26)R ₂ (39)
05.96	CN(8,5)P ₁ (14)	89.20	C ₂
7913.35	CN(2,0)P ₂ (9)	89.30	C ¹³ N(2,0)P _{1,2} (8)
13.45	CN(8,5)Q ₁ (21), (7,4)R ₁ (50)	89.50	C ¹³ N(2,0)Q ₁ (18)
13.46	CN(2,0)Q ₁ (8)	90.02	HCN v ₂ +4v ₃ -v ₂ P(13)
13.69	CN(2,0)P ₁ (2)	90.39	CN(8,5)P ₁ (25)
13.76	CN(2,0)Q ₂ (14)	90.73	Atm H ₂ O
14.25	C ₂	90.79	CN(8,5)Q ₁ (31)
14.59	HCN 3v ₁ +2v ₃ P(8)	91.11	C ¹³ N(2,0)R ₁ (28)P ₂ (15)
15.43	CN(2,0)Q ₁ (9), (8,5)Q ₂ (23)	91.58	CN(8,5)Q ₂ (32)
15.44	C ₂	91.70	C ¹³ N(2,0)P ₁ (12)
15.68	CN(7,4)Q ₁ (43)		

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