DUST AND MOLECULES ENVELOPE AROUND OF RW CYG

V. Kuz'kov

Main Astronomical Observatory, NAS of Ukraine
27 Akademika Zabolotnoho, 03680 Kyiv, Ukraine
e-mail: kuzkov@mao.kiev.ua

IR observations are important for selection dust and molecules in carbon stars. Near IR observations of RW Cyg were obtained by a small IR photometer. Observations were performed at the Peak Terskol Observatory (the Caucasus, H = 3100 m). IR observations confirm the existence of the large dust and molecules envelope with the maximum radiation at 10 micron. Comparison with radio emissions maps and far infrared survey was performed. IR excess may be caused by the C_2, CN, HCN molecules and emissions by the CO. Cooperative IR/mm waves observations will be useful for further study of this envelope.

INTRODUCTION

The RW Cyg star with the coordinates (1950) RA $= 20^h27^m01^s$, DEC $= 39°48'52''$ is situated near NGC 6913 stars formation. This is a variable star of the SR_c type with period near 586 days and amplitude $1^{m}_{.}73$ B in range $10^{m}_{.}65 \div 12^{m}_{.}38$ B and with M3 Ia (M3-4 Ia-ab [1]) spectral class.

The B, V photometrical parameters for RW Cyg are following: V $= 8^{m}_{.}4$, B $= 11^{m}_{.}5$, Sp.M5, B − V $= 3^{m}_{.}1$ [2]. For stars of M5I type the standard color is equal to $(B-V)_0 = 1^{m}_{.}80$ and the resulting color excess is equal to $E_{B-V} = 1.3$. This excess can be explained by interstellar extinction in this direction or by dust and molecules envelope around of RW Cyg.

Study of the distribution of interstellar extinction in this direction performed in paper [3] has indicated the absence of extreme interstellar extinction in this direction. The data of viewing the nearest stars around of RW Cyg in according with catalogue [2] indicate also to this fact. Assuming that the absolute star magnitude of RW Cyg is $M_V = -7^m$, and in according with expression: $m - M = 5 \log r - 5 + R\, E_{B-V}$ and $R = 3.0$ we get the result: $r = 1995$ nc. But absence of viewing stars in the nearest region around RW Cyg at distances larger 620 nc indicates that the distance to the RW Cyg is smaller and infrared excess is determined by proper dust and molecular envelope around this star.

The observations in IR bands [4] and IR spectroscopy of RW Cyg [1] confirm the existence of large envelope with extreme radiation at 10 microns. The mass loss estimated for RW Cyg is of about 5×10^{-6} $M_\odot$/year.

NEAR IR OBSERVATIONS RW CYG

The near infrared observations of RW Cyg were performed by a small IR photometer [5] on the Zeiss-600 telescope at the Peak Terskol Observatory (the Caucasus, H = 3100 m). The detector was cooled by liquid nitrogen. The aperture photometer was as 10 arcsec. A modulation of star-background-star was performed by amplitude 30 arcsec. The instrument photometry system in compare with the standard photometry system was described in [6]. It is similar to Johnson-Mendoza-Lee photometry systems. We used GAM Cyg as a standard star. The star has Sp.F8Ib and situates at of about 9 arcmin from RW Cyg. In this way we reduced the influence of extinction and color difference from standard photometry system. The results of observations compared with data of T. Lee are in Table 1.

Table 1: Near IR data of RW Cyg

I	J	H	K	J.D.	author
3.38	2.11	0.94	0.45	2440120	[7]
–	2.12	0.97	0.47	2446686	Kuz'kov
–	±0.02	±0.02	±0.05		

Absence of the observed variability of IR data indicates that the IR radiation of large envelope greater then proper variable IR emission of the star.

THE OBSERVED MOLECULES IN ENVELOPE OF RW CYG

The observation of silicon monoxide (SiO) in the envelope of RW Cyg was performed in the spectral region 3.98 – 4.07 microns, which includes the (2.0) and (3.1) rotation-vibration bands [8]. The observation has indicated the absorption at 4.00 and 4.05 microns. Comparison with synthetic spectra was performed too.

The measurements of the strength of the CO absorption band [2.35]–[2.2] Color index of RW Cyg were performed by Kenyon S. J. [9] using CVF infrared photometry. Color index [2.35]–[2.2] is measured as +0.50. The same observations of the CO absorption of RW Cyg were performed by using the two narrow band ($\Delta\lambda = 0.10\,\mu$m) filters centered at 2.17 and 2.4 microns [10].

THE FAR IR CHARACTERISTICS (IRAS)

The far infrared observations of RW Cyg were performed by IRAS too. Far infrared fluxes in Janskys are [11] as follows:

	$12\,\mu$m	$25\,\mu$m	$60\,\mu$m	$100\,\mu$m	V–K
1.	298.40	189.80	60.69	96.93	7.67
2.	298.14	202.44	53.82		

The interesting fact is that the far infrared flux at $100\,\mu$m is greater than at $60\,\mu$m. It can be explained by the additional emission of some molecules in far infrared band, for example, emission of OH at 3000 GHz. The characteristics of circumstellar shells at $60\,\mu$m derived by IRAS have indicated the absence of the extended envelope or this envelope has been not resolved by IRAS. But a peak intensity is estimated as 150×10^{-14} W m^{-2}. What is the source of this intensity?

The low resolution infrared spectrometer quantity f8 μm/f13 μm is equal to 1.40 and blackbody temperature is equal to 325 K.

THE RADIO MAPS AND IR/MM LINES

A comparison with the far infrared survey [12] and radio maps was performed. The FIR6 source exists near RW Cyg which is associated with 2.7 GHz radio continuum emission.

Comparison with the maps of various velocity ranges of the CO line has indicated that there are not a direct association with the CO molecular clouds.

Another IR and radio lines [13], for example, which can be observed in the envelope of RW Cyg are as follows:

C_2 transitions at 1.46 μm, and at 1.78 μm; CN transitions at 1.10 μm, and at 1.45 μm; CO_2 transition at 4.25 μm; HCN transition J=4-3 rot at 840 μm; H_2CO 5(1.5)–4(1.4) at 351.77 GHz (0.85 mm); HCN J(1-0) at 88.6 GHz (3.4 mm); H_2S 1_{10}-1_{01} at 169 GHz (1.8 mm); H_2S 2_{20}-2_{11} at 217 GHz (1.4 mm); H_2CO 3_{12}-3_{11} at 226 GHz (1.3 mm); HCN J(3-2) at 266 GHz (1.1 mm).

COOPERATIVE RADIO AND IR INVESTIGATIONS

Due to a close displacement of lines of various molecules in the IR band, it is difficult to perform the identification of these lines without observations in radio and optical bands. Future far infrared and mm/submm space telescope missions will be useful for the further investigation of these molecules.

There are some opportunities in performance of the onground observations. The optical mirror of the telescope is the ideal one in far IR and short mm wave bands, when the diffraction limit resolution is achieved simultaneously. The dichroic element would be a photolitography grate reflecting all waves larger 0.8 mm towards the second channel. The IR/visible waves pass across the dichroic element at the first channel. We could use infrared detectors in the first channel and radiometer mm detectors in the second one [14]. The cooperative synchronized observations in the short mm and IR bands will be performed in this way by using the ordinary optical telescope. The further IR/mm studies of the RW Cyg envelope will be useful too.

REFERENCES

[1] *Merrill K. M., Stain N. A., et al.* 2-14 micron Stellar Spectrophotometry // Publs Astron. Soc. Pacif.–1976.–**88**, N 2.–P. 285–293.

[2] *Voroshilov V. I., Guseva N. G., et al.* Catalogue B-V data and spectral classification of 18000 stars before 12^m.–Kiev, 1976.

[3] *Kalandadze N. B., Kolesnik L. N., et al.* Space distribution of stars and dust in the direction l=76$^\circ\!\!.$9, b=+0$^\circ\!\!.$6 // Astrometry and Astophys.–1977.–N 32.–P. 57–67.

[4] *Gehrz R. D., Woolf N. J., et al.* Mass Loss from M-stars // Astrophys. J.–1971.–**165**.–P. 285–294.

[5] *Kuz'kov V. P., et al.* J, H, K, L Photometer for Field Use // Kinematics and Physics of Celestial Bodies.–1989.–**5**, N 2.–P. 74–76.

[6] *Kuz'kov V. P., et al.* J, H, K photometry of CH star HD188650 // Kinematics and Physics of Celestial Bodies.–1997.–**13**, N 5.–P. 93–95.

[7] *Lee T. A., et al.* Photometry of High Luminosity M-type Stars // Astrophys. J.–1970.–**162**.–P. 217–238.

[8] *Rinsland C. P., Wing R. F., et al.* Observations of the First-Overtone Silicon Monoxide Bands in Late Type Stars // Astrophys. J.–1982.–**262**, N 1.–P. 201–212.

[9] *Kenyon S. J. and Gallagher J. S., et al.* Infrared Spectroscopy of Symbiotic Stars and nature of their cool components // Astron. J.–1983.–**88**, N 5.–P. 666–673.

[10] *Kenyon S. J., et al.* The Cool Components of Symbiotic Stars II. Infrared Photometry // Astron. J.–1988.–**96**, N 1.–P. 337–345.

[11] *Stencel R. E., Pesce J. E., et al.* Infrared circumstellar shells: origins and clues to the evolution of massive stars // Astron. J.–1989.–**97**, N. 4.–P. 1120–1138.

[12] *Campbell M. F., Hoffmann W. F., Thronson H. A., et al.* Far Infrared Survey of Cygnus X // Astrophys. J.–1980.–**238**.–P. 122–132.

[13] *Feston M. C., Rickman H., West R. M., et al.* Comets // ESO Scientific preprint.–1993.–N 960.

[14] *Kuz'kov V. P., Kudelja A. M., Larkin S. Yu., et al.* The rapid multichannel system for infrared and mm wave investigations // Proc. SPIE Intern. Conf, Kyiv, Ukraine, 1995.–**2648**.–P. 761–764.