

## SPECTROSCOPIC OBSERVATIONS OF SOME INFRARED OBJECTS

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*Received 1973 May 24*

### ABSTRACT

Low-resolution ( $495 \text{ Å mm}^{-1}$ ) spectrograms covering the spectral region 5000–9000 Å are described for 13 infrared objects. Four of the objects which have not previously been observed are M-type stars, one of which may be a Mira variable and a member of the cluster NGC 2368.

*Subject headings:* infrared sources — late-type stars — spectral classification

### I. INTRODUCTION

Subsequent to initial reports on a few extremely red stars (Neugebauer, Martz, and Leighton 1965; Ulrich *et al.* 1966), approximately 20,000 infrared objects discovered in a survey at  $2 \mu$  were compiled in a catalog of infrared sources (IRC objects) (Neugebauer and Leighton 1969). Though many IRC objects were identified in the original report with known red variables in the *General Catalog of Variable Stars* (Kukarkin *et al.* 1970), all but 235 of the remaining IRC objects were later identified with red stars previously discovered and classified in a low-dispersion spectroscopic survey of the northern sky many years ago at the Dearborn Observatory (Gaustad and Grasdalen 1971). As part of a program to obtain low-dispersion spectra of IRC objects, we report here on 13 of them, four of which have no previous spectroscopic observations.

### II. OBSERVATIONS

All observations were obtained with the 40-inch (1-m) telescope at the Wise Observatory. The dispersion of the red (5000–9000 Å) image-tube spectrograms was  $495 \text{ Å mm}^{-1}$  and the resolution,  $\lambda/\Delta\lambda \sim 1000$ .

### III. DISCUSSION

The IRC objects which were observed are listed in table 1. All spectral types were determined by direct comparison with spectra of late-type standards. The standards used were: for M6, Z Cnc; for M7, Y UMa; for M8, RX Boo; for M9,  $\alpha$  Ceti at predicted minimum in 1972 December; and for M10, R Cas at  $m_v \sim 13$  in 1973 February. The only stellar features observable at the resolution of our spectra are molecular bands attributable to TiO and VO in the M stars and CN and  $C_2$  in the carbon stars. The classification of the M-type stars is determined from the VO/TiO band strength ratios (Sharpless 1956; Wyckoff 1970). In addition to the spectral types listed in table 1 are literature references to previous spectral classifications. It is difficult to intercompare our spectral types with previous classifications of these stars since the spectral criteria were different. Furthermore, most stars probably have variable spectra. However, CIT 14 was classified as M3 in the Dearborn Survey (Gaustad 1972), and we find a significantly different type which may indicate that the star is a Mira variable. Even if CIT 14 is a long-period variable, it has an exceptionally red color,  $I - K = 5.38$ , for its spectral type, and this fact may be indicative of reddening attributable to a circumstellar dust shell.

TABLE 1  
OBSERVATIONS OF INFRARED OBJECTS

STAR	1950		DATE OBSERVED		Sp.	Ref.	REMARKS
	R.A.	Decl.	(UT)	(JD 2,440,000 +)			
RW And.....	00 <sup>h</sup> 44 <sup>m</sup> .6	+ 32°24'9"	1972 Nov. 26	1648.5	M10	1	IRC + 30015, CIT 2, predicted minimum 1972 Oct. 19
CIT 4.....	02 31.7	+ 64 56.6	1972 Nov. 23	1644.5	M7	2	IRC + 60092
CIT 5.....	03 23.0	+ 47 21.5	1972 Oct. 30	1621.5	C	2, 5	IRC + 50096
IRC - 10162...	07 18.6	- 10 16.6	1972 Nov. 27	1649.5	M7		
			1973 Jan. 13	1696.4	M9		
IRC - 30125...	08 22.9	- 30 13.1	1972 Nov. 27	1649.6	M5		
WX Ser.....	15 25.5	+ 19 44.1	1973 Apr. 2	1775.5	M7	2, 3	IRC + 20281, CIT 7, near maximum light
RU Her.....	16 08.1	+ 25 12.0	1973 Apr. 3	1776.5	M9	2, 3, 5	IRC + 30283, CIT 8, predicted minimum 1973 May 26
MW Her.....	17 33.4	+ 15 36.9	1973 Apr. 3	1776.6	M8	2, 3	IRC + 20328, CIT 9
IRC - 10490...	19 08.8	- 09 32.8	1972 Dec. 19	1671.2	M4		
RS Peg.....	22 09.8	+ 14 21.3	1972 Nov. 22	1644.3	M9	4, 5	IRC + 10514
IRC + 50449...	22 49.8	+ 50 42.4	1972 Dec. 19	1671.2	M6		
IRC + 60412...	23 30.1	+ 61 50.0	1972 Dec. 19	1671.4	C	5	
CIT 14.....	23 42.6	+ 43 38.5	1972 Dec. 19	1671.5	M7	2, 3, 5	IRC + 40545

REFERENCES.—(1) Keenan 1966; (2) Pesch 1967; (3) Wisniewski *et al.* 1967; (4) Wyckoff and Wehinger 1971; (5) Gaustad 1972; Lee *et al.* 1947.

Although the five objects listed by their IRC numbers in column (1) of table 1 were selected from a list of infrared objects suspected of having diffuse appearance (Cohen 1971), no peculiarities were observed in their near-infrared spectra. From our low-dispersion spectrograms, it is not possible to classify the carbon star since the CN and C<sub>2</sub> features are very insensitive to temperature variations. The 0-0 band of the C<sub>2</sub> Swan system with head at 5165 Å is very strong in the spectrum of IRC+60412; in fact, the spectrum closely resembles that of the cool carbon star RS Cyg. Cohen (1971) has called attention to the fact that IRC-10162 lies very near the open cluster NGC 2368. The changes observed in the spectra from 1972 November to 1973 January are characteristic of spectral changes ordinarily observed in long-period variables (cf. Wyckoff 1970). Since only a few Mira variables are known to be members of clusters, it would be of interest to continue observations of this object to ascertain its type and period.

We gratefully acknowledge the very capable assistance at the telescope of Mr. Gideon Abeles and Mr. Erza Mash'al. We also acknowledge the Wise Observatory of Tel-Aviv University and Smithsonian Research Foundation grant SFC-0-3005.

## REFERENCES

- Cohen, M. 1971, *Ap. Letters*, **9**, 95.  
 Gaustad, J. E. 1972 (private communication).  
 Gaustad, J. E., and Grasdalen, G. 1971, *A.J.*, **76**, 231.  
 Keenan, P. C. 1966, *Ap. J. Suppl.*, **13**, 333.  
 Kukarkin, B. V., Kholopov, P. N., Efremov, Yu. N., Kukarkina, N. P., Kurochkin, N. E., Medvedeva, G. I., Perova, N. B., Fedorovich, V. P., and Frolov, M. S. 1970, *General Catalog of Variable Stars* (3d ed.; Moscow: Publishing House of the Academy of Sciences of the USSR).  
 Lee, O. J., Baldwin, R. B., Hamlin, D. W., Bartlett, T. J., and Gore, G. D. 1947, *Ann. Dearborn Obs.*, **5**.  
 Neugebauer, G., and Leighton, R. B. 1969, *Two-Micron Sky Survey: A Preliminary Catalog* (NASA, SP-3047).  
 Neugebauer, G., Martz, D. E., and Leighton, R. B. 1965, *Ap. J.*, **142**, 399.  
 Pesch, P. 1967, *Ap. J. (Letters)*, **149**, L65.  
 Sharpless, S. 1956, *Ap. J.*, **124**, 342.  
 Ulrich, B. T., Neugebauer, G., McCammon, D., Leighton, R. B., Hughes, E. E., and Becklin, E. 1966, *Ap. J.*, **146**, 288.  
 Wisniewski, W. Z., Wing, R. F., and Johnson, H. L. 1967, *Ap. J. (Letters)*, **148**, L29.  
 Wyckoff, S. 1970, *Ap. J.*, **162**, 203.  
 Wyckoff, S., and Wehinger, P. 1971, *Ap. J.*, **164**, 383.