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NEWLY IDENTIFIED INFRARED CARBON STARS FROM THE *IRAS* LOW-RESOLUTION SPECTRA

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ABSTRACT

We report new identifications of 63 infrared carbon stars and 24 possible candidates based on the presence of the SiC emission feature at 11.2 μm in their *IRAS* low-resolution spectra and on their infrared colors. The *IRAS* spectra of the newly identified carbon stars are presented.

Key words: infrared radiation — stars: AGB and post-AGB — stars: carbon

1. INTRODUCTION

The spectral classes of M, S, and C are believed to be an evolutionary sequence for most stars on the asymptotic giant branch (AGB; Iben & Renzini 1983; Chen & Kwok 1993). In this scenario, an initially oxygen-rich (C/O < 1) M star would, as a result of carbon dredge-up from its interior, evolve through a spectral type of S (C/O ≈ 1) to become a carbon-rich (C/O > 1) star. The dredge-up causes carbon to bind with oxygen to form CO molecules, leaving insufficient carbon atoms to produce other carbon-rich material. As the oxygen-rich circumstellar envelope dissipates into the interstellar medium and more carbon-rich material is brought up, the star gradually becomes a visual carbon star. The accumulation of carbon atoms in the photosphere leads to the formation of carbon-rich dust grains, such as amorphous carbon or silicon carbide (SiC). A carbon-rich dust envelope then forms, and the star becomes a so-called infrared carbon star, characterized by an emission feature at 11.2 μm due to stretching bands of solid SiC (Chan & Kwok 1990; Guglielmo et al. 1993). It has been shown that candidate infrared carbon stars can be identified by their distinct location in a $K-L$ versus *IRAS* [12]−[25] color-color diagram (Fouqué et al. 1992; Guglielmo et al. 1993, 1997; Guglielmo, Le Bertre, & Epchtein 1998).

The *IRAS* mission carried on board a slitless spectrometer (the LRS) that recorded low-resolution spectra in the 7.7–22.6 μm region with a spectral resolution of about 20–60 (*IRAS* Explanatory Supplement 1988). The *IRAS* Science Team published the LRS spectra of 5425 sources, among which 538 were listed as class 4*n* (Atlas of Low Resolution *IRAS* Spectra 1986). Soon after, Little-Marenin et al. (1987) identified 176 infrared carbon stars based on the LRS 4*n* classification, which they took as an indication of the presence of the SiC emission feature at 11.2 μm. These newly identified carbon stars were subsequently included in the second edition of the General Catalogue of Cool Galactic Carbon Stars (Stephenson 1989). Chan & Kwok (1990) and Jura & Kleinmann (1990), also on the basis of LRS 4*n* classifications, added 145 and 126 infrared carbon stars, respectively, among which 14 and seven had not previously been identified. However, it is well documented that interpretation of the automated LRS classifications sometimes can be misleading (e.g., Little-Marenin et al. 1987; Baron et al. 1987; Walker & Cohen 1988; Chan & Kwok 1990; Volk et al. 1991; Groenewegen et al. 1992; Omont et al. 1993). It is therefore desirable to investigate whether the infrared carbon stars reported in the literature on the basis of their LRS spectra genuinely exhibit the SiC emission feature, and to search in the LRS database for additional infrared carbon stars with weak SiC signatures.

Kwok, Volk, & Bidelman (1997) sorted out the raw database of LRS spectra using the letter classification scheme proposed by Volk & Cohen (1989) and published an expanded LRS database in which the number of sources reached 11,224. This is more than double the size of the previous LRS Atlas, so it is expected that some previously unknown infrared carbon stars would be included in this new database and misleading identifications could be corrected. In the new LRS database, sources are sorted into 10 classes according to their spectral characteristics, among which class C is considered to have the 11.2 μm SiC emission feature. We therefore took class C as our basic working sample and inspected the *IRAS* low-resolution spectra for the SiC emission feature at 11.2 μm. All known carbon stars have been excluded from our sample. This resulted in 63 newly identified infrared carbon stars, and an additional 24 possible ones. The LRS spectra of the 63 newly identified carbon stars are presented in Figure 2 below.

2. DATA PROCESSING AND RESULTS

We started the data processing by extracting the 714 objects in group C from Kwok et al. (1997) and then cross-identified these *IRAS* sources with carbon stars reported in the third edition of Stephenson's General Catalogue of Cool Galactic Carbon Stars (CGCS3; Alksnis et al. 2001), in which almost all carbon stars known up to 2001 are included. A cross-identification was considered secured if a CGCS3 star fell within the error ellipse of an *IRAS* point source (95% reliability positional error ellipse; *IRAS* Point Source Catalog, Version 2 1988).

Every source in class 4*n* from Little-Marenin et al. (1997), Chan & Kwok (1990), and Jura & Kleinmann (1990) was checked to see whether it belongs to group C in the LRS classification scheme of Volk & Cohen (1989). It was found

TABLE 1
SOURCES NOT IN THE CGCS3 BUT PREVIOUSLY KNOWN AS CARBON STARS

No.	*IRAS* NAME	LRS	*IRAS* (B1950) R.A.	*IRAS* (B1950) Decl.	GSC/USNO (B1950) R.A.	GSC/USNO (B1950) Decl.	Refs.
1	04340+4623	C (42)	04 34 01.2	+46 23 27	...	...	1, 2
2	05261+4626	C (43)	05 26 09.1	+46 26 33	...	...	2
3	06447+0817	C (17)	06 44 42.5	+08 17 18	...	...	3
4	07113−0025	C	07 11 19.8	−00 25 48	...	...	4
5	15261−5702	C (43)	15 26 06.3	−57 02 27	15 26 08.09	−57 02 34.5	5
6	16373−4732	C	16 37 19.2	−47 32 10	16 37 19.82	−47 32 03.3	4
7	17092−3905	C	17 09 12.1	−39 05 48	17 09 13.61	−39 05 47.2	4
8	18240+2326	C (42)	18 24 01.2	+23 26 53	18 24 02.45	+23 26 53.8	6, 7, 8
9	18244−0815	C	18 24 24.0	−08 15 04	18 24 24.09	−08 15 01.9	1
10	19029+0839	C (16)	19 02 57.0	+08 39 21	19 02 58.31	+08 39 16.1	9
11	20159+3134	C (43)	20 15 58.9	+31 34 50	20 15 57.79	+31 34 55.0	2
12	20340+5338	C (42)	20 34 05.3	+53 38 54	...	...	2, 10
13	21265+5042	C (43)	21 26 30.7	+50 42 17	...	...	11

NOTE.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

REFERENCES.—(1) Kastner et al. 1993; (2) Chan & Kwok 1990; (3) Jiang et al. 1997; (4) Guglielmo et al. 1993; (5) Allen, Kleinmann, & Weinberg 1993; (6) Jura 1986; (7) Chan & Kwok 1988; (8) Groenewegen et al. 1992; (9) Barnbaum, Kastner, & Zuckerman 1991; (10) Jura & Kleinmann 1990; (11) Leahy, Kwok, & Arquilla 1987.

that four Little-Marenin et al. sources do not belong to group C but have been classified into other groups. These are IRAS 04357+4323 = CGCS 735 (in group S), IRAS 05447+1321 = CGCS 1063 (in group F), IRAS 06267+2033 = CGCS 1285 (in group U), and IRAS 06348+3114 = CGCS 1327 (in group F). It was also found that a Chan & Kwok source, IRAS 14284−5245, belongs to group F. These five sources should be deleted from the infrared carbon star list. A total of 113 objects in group C do not appear in the CGCS3, among which 13 are carbon stars already reported in the literature (Table 1) and so should also be removed from our working sample. Thus we are left with 100 stars in group C that remain as candidate infrared carbon stars.

Possible counterparts in the *Hubble Space Telescope* Guide Star Catalog (GSC; STScI 1989) or the USNO-A catalog (Monet et al. 1996) for each candidate were then searched for, and the CGCS3 and GSC/USNO magnitudes were compared in order to further ascertain the cross-identification between the CGCS3 and the *IRAS* sources. If there was more than one GSC or USNO source within the *IRAS* positional error ellipse, the USNO *B* and *R* magnitudes were used as a guide in choosing the most probable counterpart, following Bessell (1990). The GSC/USNO counterpart positions are given in Table 1.

On the other hand, van der Veen & Habing (1988) and Omont et al. (1993) have pointed out that the *IRAS* [12]−[25] versus [25]−[60] color-color diagram can be an effective and simple tool for classification of AGB and post-AGB stars. In the diagram there are 10 regions (van der Veen & Habing 1988), each occupied by a certain kind of object with distinct infrared colors. Because most carbon stars with the 11.2 μm SiC emission feature have characteristic *IRAS* colors, van der Veen & Habing were led to identify a special region in the *IRAS* color-color diagram where the majority of the sources are carbon-rich stars (their region VII; see also Omont et al. 1993). Therefore, in addition to the SiC emission feature at 11.2 μm, the location of a star in or very close to region VII was adopted as another selection criterion for candidate infrared carbon stars.

In our final sample, 60 objects out of the original 100 have good-quality fluxes at 12, 25, and 60 μm for use in the *IRAS* color-color diagram, as shown in Figure 1. It can clearly be seen that most of the sources are indeed located in or very close to region VII. Note that a 15% flux uncertainty, common for *IRAS* sources, would lead to a ±0.13 error in the color indexes. There are only about 10 sources definitely outside region VII. Furthermore, only a few sources have [12]−[25] color indexes that are not within the range of region VII. Therefore, as already pointed out by Guglielmo et al. (1997), the [12]−[25] color index alone could be a useful selection criterion for those sources with poor-quality or no *IRAS* 60 μm flux. Of the 100 sources, there are 40 such objects.

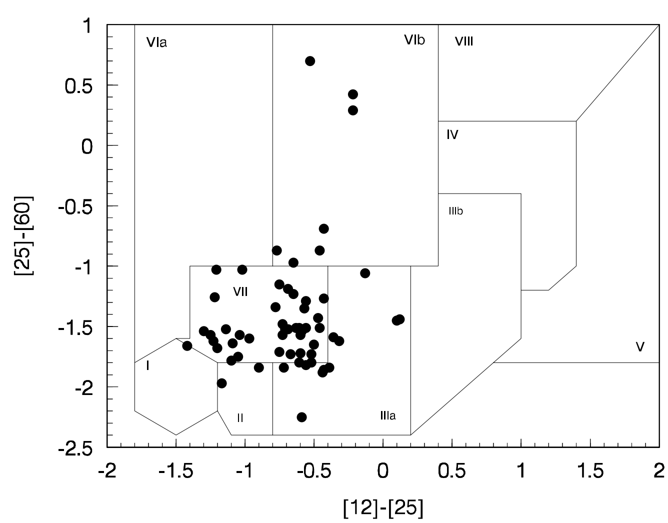

FIG. 1.—*IRAS* two-color diagram for the candidate newly identified infrared carbon stars.

TABLE 2

NEWLY IDENTIFIED CARBON STARS

No.	*IRAS* Name	LRS	*IRAS* (B1950) R.A.	*IRAS* (B1950) Decl.	GSC/USNO (B1950) R.A.	GSC/USNO (B1950) Decl.	*B*	*V*	*R*	F_{12}	F_{25}	F_{60}	Note
1	03156+5828	C (80)	03 15 40.6	+58 28 54	...	...	...	...	...	8.22	2.81	...	
2	04297+2941	C	04 29 45.2	+29 41 49	...	...	...	...	...	40.97	20.84	4.90	OH nondetection[a]
3	05342+4439	C (16)	05 34 17.2	+44 39 17	...	...	...	...	...	10.77	3.58	0.76	
4	05521−2242	C (16)	05 52 06.6	−22 42 17	05 52 06.57	−22 42 17.8	15.4	14.3	11.2	13.32	4.03	0.98	
5	06196−2409	C (16)	06 19 36.5	−24 09 55	...	...	...	...	...	11.46	5.61	1.63	
6	06585−4111	C (23)	06 58 34.4	−41 11 40	06 58 34.50	−41 11 41.7	16.2	...	10.3	29.39	10.79	2.38	
7	07036−2220	C (14)	07 03 37.2	−22 20 30	07 03 37.30	−22 20 24.5	20.2	...	18.7	18.67	10.81	2.62	
8	07085−0018	C (22)	07 08 33.7	−00 18 12	07 08 33.29	−00 18 15.9	17.7	...	15.5	36.53	18.66	4.78	SiO nondetection[b]
9	07593−1452	C (01)	07 59 20.4	−14 52 36	07 59 20.91	−14 52 37.2	19.0	13.4	10.6	12.91	3.49	0.76	
10	08017−3651	C (14)	08 01 47.7	−36 51 55	08 01 47.39	−36 51 53.9	20.7	...	18.2	9.20	5.70	1.16	
11	08107−3355	C (15)	08 10 45.3	−33 55 56	08 10 45.24	−33 55 55.2	19.8	...	13.9	10.37	3.98	0.94	
12	08195−4027	C (16)	08 19 30.1	−40 27 28	08 19 30.17	−40 27 27.7	19.5	...	17.7	16.03	8.32	2.06	
13	08546−4350	C (18)	08 54 36.4	−43 50 53	08 54 34.61	−43 50 45.3	20.5	...	17.6	9.89	4.47	...	
14	09006−5310	C (22)	09 00 41.5	−53 10 01	09 00 40.39	−53 09 58.2	19.7	...	17.8	21.07	12.61	3.13	
15	09088−5050	C (32)	09 08 50.5	−50 50 15	09 08 50.06	−50 50 07.3	16.4	...	15.9	14.42	5.36	...	
16	09238−5309	C (15)	09 23 49.5	−53 09 38	09 23 49.84	−53 09 33.5	22.7	...	19.7	25.89	14.75	2.82	OH nondetection[c]
17	10130−5703	C (14)	10 13 02.0	−57 03 49	10 13 01.57	−57 03 54.2	21.1	...	18.4	24.30	13.68	...	
18	10255−5559	C (14)	10 25 33.0	−55 59 40	10 25 31.10	−55 59 27.3	21.5	...	18.3	15.69	9.27	2.68	
19	10591−5848	C (15)	10 59 10.2	−58 48 59	10 59 11.04	−58 49 18.8	17.2	...	14.0	17.53	11.32	...	
20	11079−6211	C (44)	11 07 58.3	−62 11 33	...	...	...	...	...	21.87	14.37	3.59	OH nondetection[c]
21	11496−6136	C (16)	11 49 39.9	−61 36 59	11 49 39.66	−61 36 54.4	21.7	...	19.1	18.57	10.05	2.04	
22	12142−6410	C (15)	12 14 15.6	−64 10 29	12 14 16.62	−64 10 31.9	11.9	11.7	13.2	21.92	13.07	2.44	OH nondetection[c]
23	12352−6317	C (15)	12 35 15.0	−63 17 08	12 35 15.99	−63 17 25.2	22.6	...	18.5	19.88	14.79	3.34	OH nondetection[c]
24	12407−6234	C	12 40 46.5	−62 34 35	12 40 43.91	−62 34 35.9	22.2	...	17.9	11.51	2.74	...	
25	12533−6118	C	12 53 23.4	−61 18 25	12 53 22.2	−61 18 23.6	23.2	...	20.6	31.31	20.81	3.67	OH nondetection[c]
26	14358−6303	C (14)	14 35 51.2	−63 03 08	14 35 53.64	−63 03 05.1	20.4	...	16.8	57.53	38.31	7.89	OH nondetection[c]
27	14457−5836	C	14 45 43.7	−58 36 46	14 45 46.27	−58 36 44.2	21.7	...	16.6	13.76	5.81	...	
28	15312−5821	C	15 31 16.2	−58 21 30	15 31 17.26	−58 21 26.7	19.5	...	16.5	10.95	6.54	2.00	
29	16081−5042	C	16 08 09.1	−50 42 39	16 08 08.85	−50 42 32.6	...	10.4	10.4	91.52	45.91	...	
30	16409−4500	C	16 40 58.1	−45 00 18	16 45 57.61	−45 00 17.7	21.9	...	17.6	15.13	6.18	...	
31	16473−4041	C	16 47 19.1	−40 41 10	16 47 18.72	−40 41 07.7	17.7	...	11.2	10.30	3.62	...	
32	17120−3939	C	17 12 03.3	−39 39 48	17 12 05.67	−39 39 47.5	20.4	...	17.2	13.68	9.97	...	
33	17151−3629	C	17 15 09.2	−36 29 19	17 15 11.37	−36 29 18.7	20.5	...	16.9	12.88	5.03	...	
34	17199−3512	C (32)	17 19 59.5	−35 12 53	...	...	...	...	...	92.21	51.69	12.91	
35	18008−2840	C (01)	18 00 51.2	−28 40 53	18 00 51.33	−28 40 50.5	18.1	...	17.8	10.36	4.41	...	
36	18110−1909	C	18 11 00.5	−19 09 20	18 11 02.01	−19 09 26.4	17.6	...	15.7	48.42	20.04	...	
37	18250−1818	C	18 25 02.2	−18 18 04	18 25 01.10	−18 18 07.4	19.8	...	16.4	9.88	4.24	...	
38	18356−0951	C	18 35 40.3	−09 51 42	18 35 41.33	−09 51 41.9	19.7	...	16.5	55.08	28.30	5.18	
39	18379−0417	C	18 37 55.0	−04 17 42	18 37 56.31	−04 17 31.2	20.5	...	17.4	12.36	7.16	...	
40	18487+0135	C (17)	18 48 43.7	+01 35 32	...	...	...	...	...	19.27	8.19	...	

TABLE 2—*Continued*

No.	*IRAS* Name	LRS	*IRAS* (B1950) R.A.	*IRAS* (B1950) Decl.	GSC/USNO (B1950) R.A.	GSC/USNO (B1950) Decl.	*B*	*V*	*R*	F_{12}	F_{25}	F_{60}	Note
41	18542+0430	C (15)	18 54 14.5	+04 30 13	18 54 15.33	−04 30 14.1	20.9	...	17.0	10.24	6.55	...	OH nondetection[d]
42	19109+0657	C (50)	19 10 57.9	+06 57 47	19 10 57.93	+06 57 50.6	21.1	...	17.3	14.16	4.80	0.78	OH nondetection[e]
43	19151+1037	C	19 15 07.4	+10 37 58	19 15 07.24	+10 37 57.3	20.4	...	17.6	8.12	3.46	...	
44	19236+2404	C	19 23 39.4	+24 04 57	19 23 39.74	+24 04 53.6	18.2	...	16.3	7.79	5.25	0.95	OH nondetection[f]
45	19293+2002	C (50)	19 29 18.3	+20 02 07	19 29 18.44	+20 02 11.9	15.2	13.1	12.3	11.30	6.23	2.56	
46	19317+2159	C (44)	19 31 44.5	+21 59 21	...	...	...	...	...	13.35	7.85	1.50	
47	19363+2652	C (01)	19 36 18.3	+26 52 12	19 36 18.67	+26 52 15.0	18.7	...	16.0	10.28	5.45	1.35	OH nondetection[a]
48	19399+2404	C (16)	19 39 56.3	+24 04 40	19 39 55.27	+24 04 35.9	19.1	...	16.3	8.07	2.57	...	
49	19455+2319	C (44)	19 45 31.2	+23 19 06	19 45 31.95	+23 19 10.4	15.3	13.2	12.7	27.36	16.91	3.21	OH nondetection[d]
50	19470+2603	C	19 47 04.5	+26 03 34	19 47 04.93	+26 03 37.3	12.4	11.9	12.2	10.93	7.08	1.89	OH nondetection[d]
51	19485+3235	C	19 48 32.6	+32 35 52	19 48 31.10	+32 35 46.1	17.5	...	13.9	29.96	21.00	3.87	OH nondetection[d]
52	19535+2635	C (44)	19 53 34.1	+26 35 09	19 53 33.79	+26 35 17.8	13.4	13.1	12.9	13.44	5.25	2.04	
53	19541+2807	C (17)	19 54 08.3	+28 07 05	19 54 09.92	+28 07 01.5	19.1	...	16.5	14.57	8.36	1.96	OH nondetection[d]
54	20080+4022	C	20 08 04.0	+40 22 12	20 08 04.74	+40 22 29.6	19.7	...	17.3	8.10	4.25	...	
55	20108+3347	C	20 10 50.9	+33 47 29	20 10 50.47	+33 46 49.9	19.6	...	17.7	8.31	3.06	...	
56	20185+3848	C (15)	20 18 32.5	+38 48 59	...	...	...	...	...	17.32	9.52	3.07	
57	20228+3558	C	20 22 49.7	+35 58 27	...	...	...	...	...	20.55	4.60	...	
58	20333+3746	C (45)	20 33 21.7	+37 46 50	20 33 21.19	+37 46 48.4	20.9	...	17.8	13.93	4.59	1.77	
59	20379+4036	C	20 37 57.3	+40 36 19	...	...	...	...	...	27.58	14.92	...	
60	20391+4023	C (43)	20 39 09.1	+40 23 13	20 39 10.44	+40 23 31.1	15.3	13.5	13.9	21.32	9.36	...	
61	20424+5921	C (16)	20 42 29.4	+59 21 59	...	...	...	...	...	11.54	4.19	0.81	
62	22395+5831	C (17)	22 39 34.5	+58 31 39	...	...	...	...	...	16.98	5.51	1.58	
63	22562+6310	C (15)	22 56 17.6	+63 10 28	...	...	...	...	...	14.12	7.03	2.43	

[a] Lewis 1994.
[b] Jiang et al. 1996.
[c] Te Lintel Hekkert et al. 1991.
[d] Chengalur et al. 1993.
[e] Sivagnanam et al. 1990.
[f] Lewis, Eder, & Terzian 1990.

TABLE 3

POSSIBLE CARBON STARS

No.	*IRAS* NAME	LRS	*IRAS* (B1950) R.A.	*IRAS* (B1950) Decl.	GSC/USNO (B1950) R.A.	GSC/USNO (B1950) Decl.	*B*	*V*	*R*	F_{12}	F_{25}	F_{60}	NOTE
1	00050+7357	C	00 05 05.1	+73 57 41	00 05 11.57	+73 57 45.9	20.3	...	16.5	7.45	2.40	0.54	Noisy
2	01022+6542	C	01 02 12.6	+65 42 54	01 02 12.75	+65 42 56.0	19.7	...	13.9	20.36	8.19	0.80	Could also be F[a]
3	01327+6503	C (16)	01 32 45.1	+65 03 20	01 32 46.85	+65 03 19.6	17.9	...	15.0	11.86	5.97	1.24	Very noisy[a]
4	06242+2830	C (14)	06 24 15.2	+28 30 20	...	...	...	...	...	17.77	11.18	2.44	Noisy[a]
5	07439−3612	C	07 43 55.7	−36 12 24	07 43 55.91	−36 12 04.4	16.5	...	13.6	10.79	7.73	1.78	Noisy[a]
6	08151−3934	C (15)	08 15 11.4	−39 34 19	...	...	...	...	...	16.94	9.62	2.39	Noisy[a]
7	08363−4837	C (01)	08 36 20.9	−48 37 32	08 36 20.64	−48 37 33.1	11.2	...	9.1	8.79	3.59	0.82	Noisy[a]
8	10239−5818	C (15)	10 23 54.2	−58 18 24	10 23 54.64	−58 18 35.5	11.4	...	9.9	38.45	25.73	7.97	Could also be F[a]
9	11251−5946	C	11 25 10.0	−59 46 45	11 25 09.47	−59 46 40.9	16.6	...	15.2	8.24	3.31	...	Noisy[a]
10	13366−6338	C	13 36 38.9	−63 38 53	13 36 38.57	−63 38 51.1	...	12.8	...	12.21	6.23	...	Noisy
11	14063−6104	C	14 06 19.1	−61 04 24	14 06 18.64	−61 04 30.4	21.2	...	18.2	38.86	34.25	12.90	Region IIIa
12	16229−4947	C (43)	16 22 54.4	−49 47 42	16 22 55.68	−49 47 45.5	22.4	...	18.9	24.03	29.93	...	Region IIIa
13	16567−2408	C (16)	16 56 43.4	−24 08 24	16 56 43.23	−24 08 25.0	17.4	...	15.2	14.56	5.09	1.25	Could also be F[a]
14	17252−3359	C	17 25 17.4	−33 59 02	17 25 15.37	−33 58 52.7	23.3	...	17.8	11.39	6.45	...	Noisy[a]
15	17314−3314	C	17 31 25.2	−33 14 22	17 31 24.88	−33 14 24.2	22.2	...	18.6	34.20	20.85	...	Could also be F
16	17594−1910	C (43)	17 59 25.3	−19 10 37	17 59 24.10	−19 10 44.4	18.4	...	15.6	28.13	14.21	...	Could also be F
17	19118+1020	C (15)	19 11 48.9	+10 20 34	19 11 49.85	+10 20 38.9	20.3	...	16.0	9.38	3.70	...	Questionable[a]
18	19240+2322	C (14)	19 24 01.9	+23 22 42	19 24 03.33	+23 22 50.3	18.4	...	15.6	14.59	8.36	1.71	Could also be F[a]
19	20091+3645	C	20 09 07.8	+36 45 20	20 09 07.64	+36 45 28.3	17.9	...	15.6	9.03	3.15	...	Noisy
20	21136+5705	C (18)	21 13 37.7	+57 05 36	...	...		...	18.17	5.72	1.35	...	Noisy[a]
21	21167+5148	C	21 16 47.3	+51 48 37	...	...		...	9.38	6.17	...	...	Noisy[a]
22	23086+6325	C	23 08 40.8	+63 25 50	23 08 41.93	+63 26 06.1	19.6	...	17.0	11.05	4.20	0.84	Could also be F
23	23148+6836	C	23 14 48.9	+68 36 24	...	...		...	8.92	3.88	0.71	...	Could also be F[a]
24	23183+6151	C	23 18 23.4	+61 51 45	23 18 24.01	+61 51 56.0	17.9	...	14.5	8.11	4.31	1.44	Noisy[a]

[a] Kwok et al. 1997.

TABLE 4

SUSPECTED CARBON STARS

			IRAS (B1950)		GSC/USNO (B1950)								
No.	*IRAS* Name	LRS	R.A.	Decl.	R.A.	Decl.	B	V	R	F_{12}	F_{25}	F_{60}	Note
1	12139−6103	C	12 13 57.6	−61 03 45	12 13 56.17	−61 03 32.6	18.4	...	15.1	7.18	4.72	2.11	Noisy, VIb[a]
2	13064−6433	C (42)	13 06 25.5	−64 33 56	13 06 24.55	−64 34 00.1	20.0	...	17.4	23.76	26.13	6.86	Noisy, IIIa
3	14061−5839	C	14 06 06.8	−58 39 44	14 06 09.18	−58 39 52.9	21.2	...	18.9	7.52	3.70	1.66	Noisy, VIb[a]
4	15057−5934	C	15 05 43.9	−59 34 41	15 05 44.49	−59 34 42.3	20.5	...	17.2	10.47	11.73	3.10	Noisy, IIIa
5	16136−5020	C	16 13 41.9	−50 20 00	16 13 43.59	−50 19 59.5	19.5	...	16.9	8.63	8.92	...	Questionable, IIIa
6	16210−4957	C (49)	16 21 00.7	−49 57 00	16 21 00.60	−49 57 01.2	20.8	...	18.6	10.99	8.96	11.65	Questionable, VIb[a]
7	16455−4349	C (73)	16 45 34.1	−43 49 41	16 41 32.85	−43 49 36.2	21.1	...	18.3	28.30	18.96	10.03	Questionable, VIb[a]
8	16458−4425	C	16 45 50.0	−44 25 07	16 45 49.55	−44 24 59.1	17.6	...	16.1	8.63	7.55	...	Noisy, IIIa[a]
9	16589−4024	C	16 58 58.5	−40 24 39	16 58 59.04	−40 24 36.2	20.2	...	17.6	8.80	7.18	10.60	Noisy, VIb[a]
10	18040−2028	C	18 04 05.4	−20 28 34	18 04 04.34	−20 28 07.9	19.3	...	14.8	8.67	5.34	10.07	Noisy, VIb
11	18111−1645	C	18 11 08.1	−16 45 13	18 11 07.64	−16 45 09.8	20.6	...	16.5	13.98	17.19	...	Noisy, IIIb
12	19315+1807	C	19 31 32.5	+18 07 21	19 31 33.77	+18 07 16.3	20.8	...	18.3	16.72	13.84	...	Noisy, IIIa
13	19429+2721	C	19 42 54.6	+27 21 16	19 42 55.48	+27 21 12.6	19.4	...	17.8	12.47	7.22	0.91	Noisy, IIIa

[a] Kwok et al. 1997.

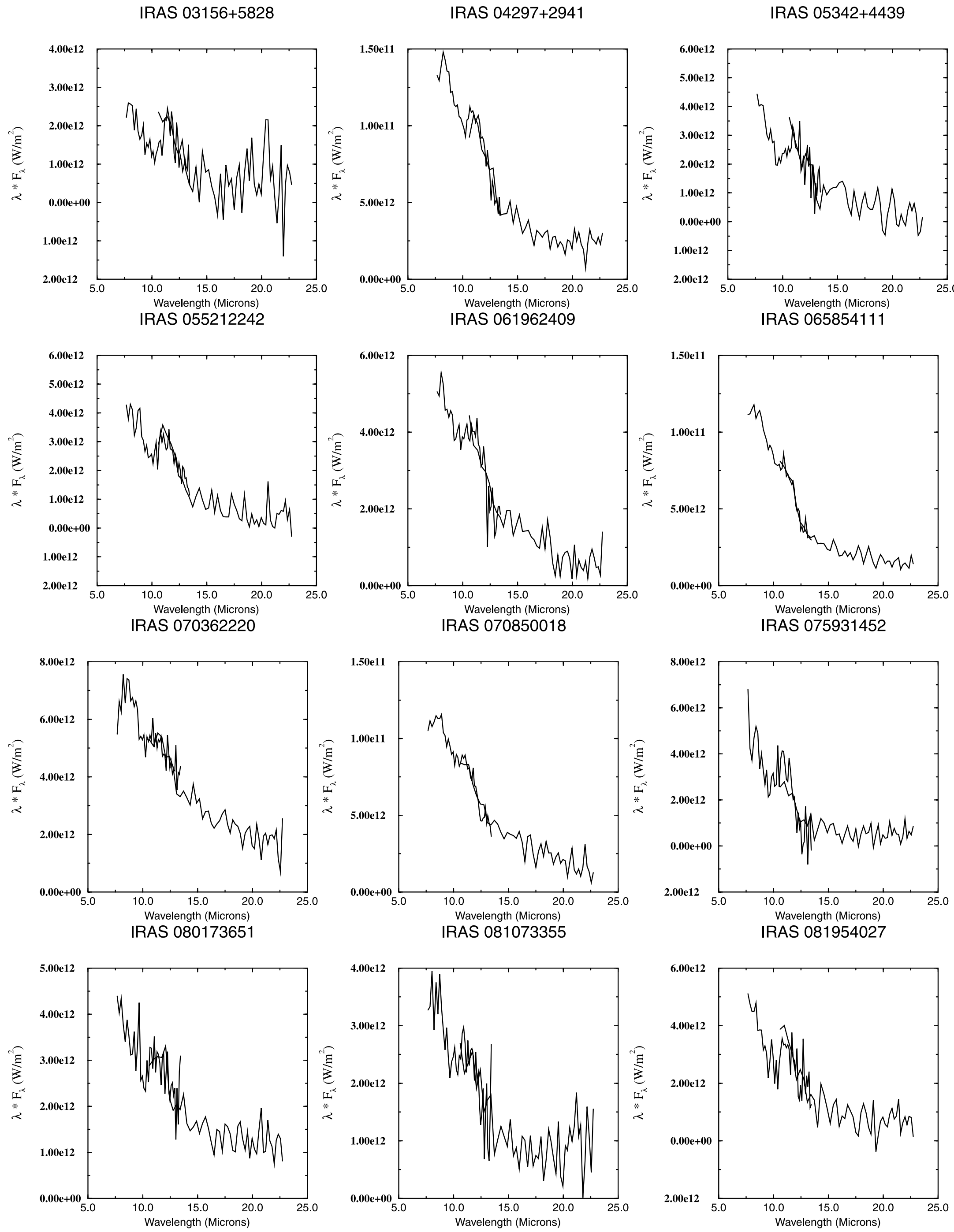

FIG. 2.—*IRAS* low-resolution spectra of the 63 newly identified infrared carbon stars

From our final sample of 100 sources, we therefore selected as newly identified infrared carbon stars those with a clear presence of the SiC emission feature at 11.2 μm, *and* with *IRAS* colors within region VII or, for those lacking a 60 μm flux, with their [12]–[25] colors within the range of region VII. A total of 63 such candidate carbon stars have been found, and they are listed in Table 2. Their LRS spectra from Kwok et al. (1997) are presented in Figure 2.

In Table 2, the first three columns give respectively a running number, the *IRAS* name, and the LRS classification from Kwok et al. (1997) and the LRS Atlas index (if any). The next two columns list the *IRAS* coordinates, followed by the GSC or the USNO position. The next three columns give B, V, and R magnitudes taken from the GSC or the USNO catalog, followed by the 12, 25, and 60 μm fluxes in janskys from the *IRAS* Point Source Catalog; only fluxes that were flagged as good-quality are listed. The last column indicates the results of searches for 1612 MHz hydroxyl or SiO maser emission. Among the 16 sources that have been observed, none were detected.

In Table 2, it can be seen that 22 out of the 63 sources are not listed in the *IRAS* Atlas but are present in the new LRS database. In addition, some sources belong to class 1n or 2n in the *IRAS* Atlas. This is hardly surprising, because as

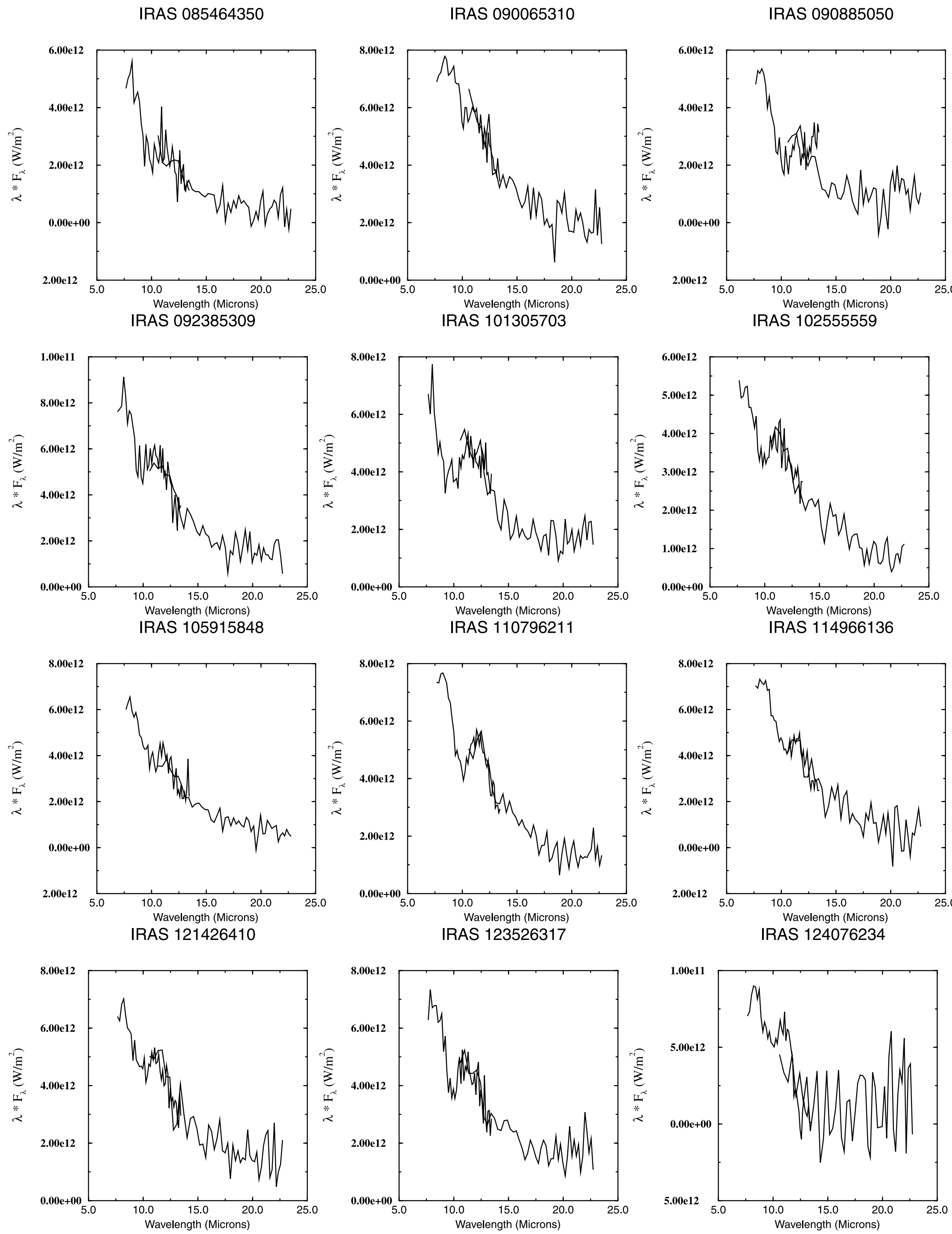

FIG. 2.—*Continued*

pointed out in the Atlas, sources with index 14–16 may have carbon-rich envelopes. Baron et al. (1987) and Omont et al. (1993) suggested that among class 1*n* and 2*n* sources, many would actually be carbon stars that display weak emission at 11.2 μm. To test this, we investigated the LRS spectra of a class 1*n* source, IRAS 10255−5559, and a class 2*n* source, IRAS 07085−0018, in detail. After matching a blackbody energy distribution to the continuum around 11 μm and subtracting it, in each case the 11.2 μm emission feature is evident (Fig. 3).

Presented in Table 3 (with the same structure as Table 2) are 24 additional possible infrared carbon stars. Sources listed in Table 3 either have noisy or ambiguous LRS spectra (albeit being classified in group C according to Kwok et al. 1997, and located in region VII in Fig. 1) or have good-quality LRS spectra but are located in region IIIa, which Omont et al. (1993) suggested as a possible location for cool carbon stars. Finally, 13 sources suspected to be infrared carbon stars are listed in Table 4, again with the same structure as Table 2. All sources listed in Table 4 have poor-quality LRS spectra but were classified in group C by Kwok et al. (1997), and all fall outside of region VII.

In Table 3, IRAS 16229−4947 is listed as a possible infrared carbon star though Epchtein, Le Bertre, & Lépine (1990)

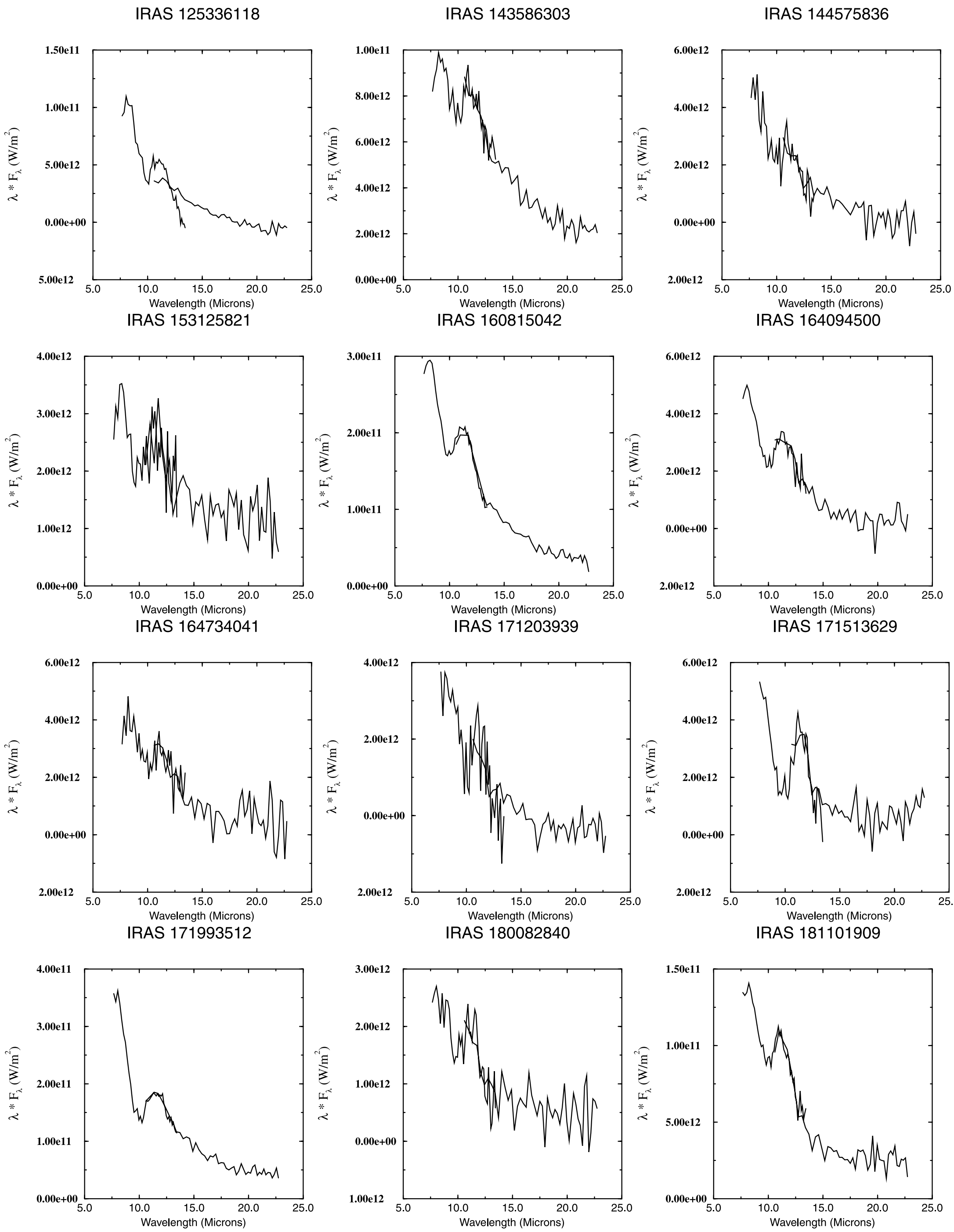

FIG. 2.—*Continued*

considered it to be a probable oxygen-rich star by virtue of its location in the $K-L$ versus [12]−[25] diagram. Additional sources that should be noted are IRAS 13064−6433 and IRAS 16210−4957, listed in Table 4 as suspected carbon stars. Both sources are located in the $K-L$ versus [12]−[25] diagram in a region mainly populated with oxygen-rich stars (Epchtein et al. 1990). However, Groenewegen et al. (2002) recently made CO (1–0) and CO (2–1) observations of IRAS 13064−6433, which indicate that it should be a carbon star. Regarding IRAS 16210−4957, Buss, Tielens, & Snow (1991) have pointed out that it might not be a carbon-rich giant. In order to clarify the chemical nature of IRAS 16229−4947 and IRAS 16210−4957, further observations with higher spectral resolution in the infrared or at millimeter wavelengths are needed.

3. SUMMARY

We have compiled a list of candidate carbon stars by inspection of the 11.2 μm SiC emission feature in the latest *IRAS* LRS database (Kwok et al. 1997) and by use of their characteristic *IRAS* colors. A total of 63 infrared carbon stars, plus 24 possible ones, have been identified. Our contribution enlarges the sample of known carbon stars, which

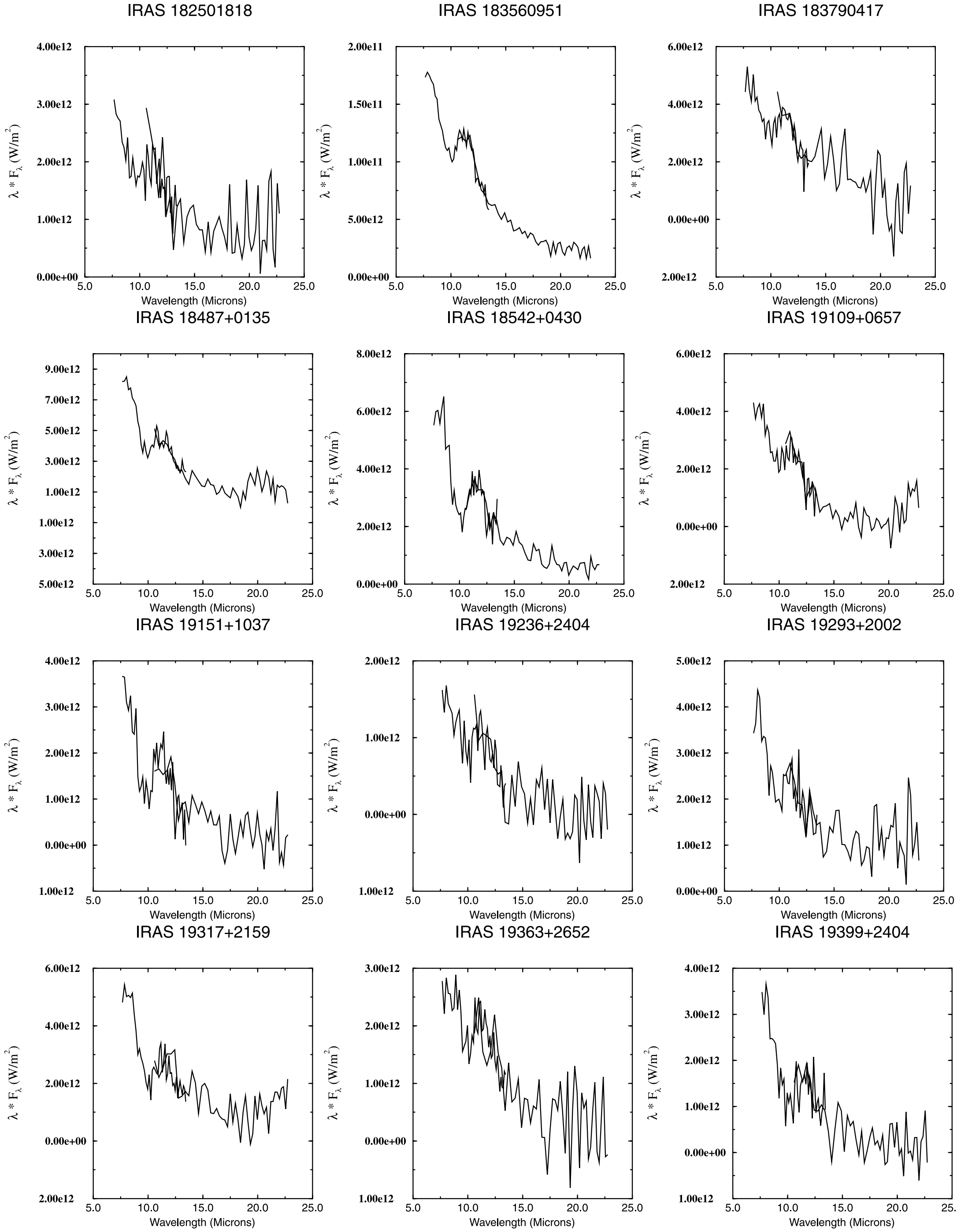

FIG. 2.—*Continued*

serves as a basis for further observations and statistical study of various species of AGB stars.

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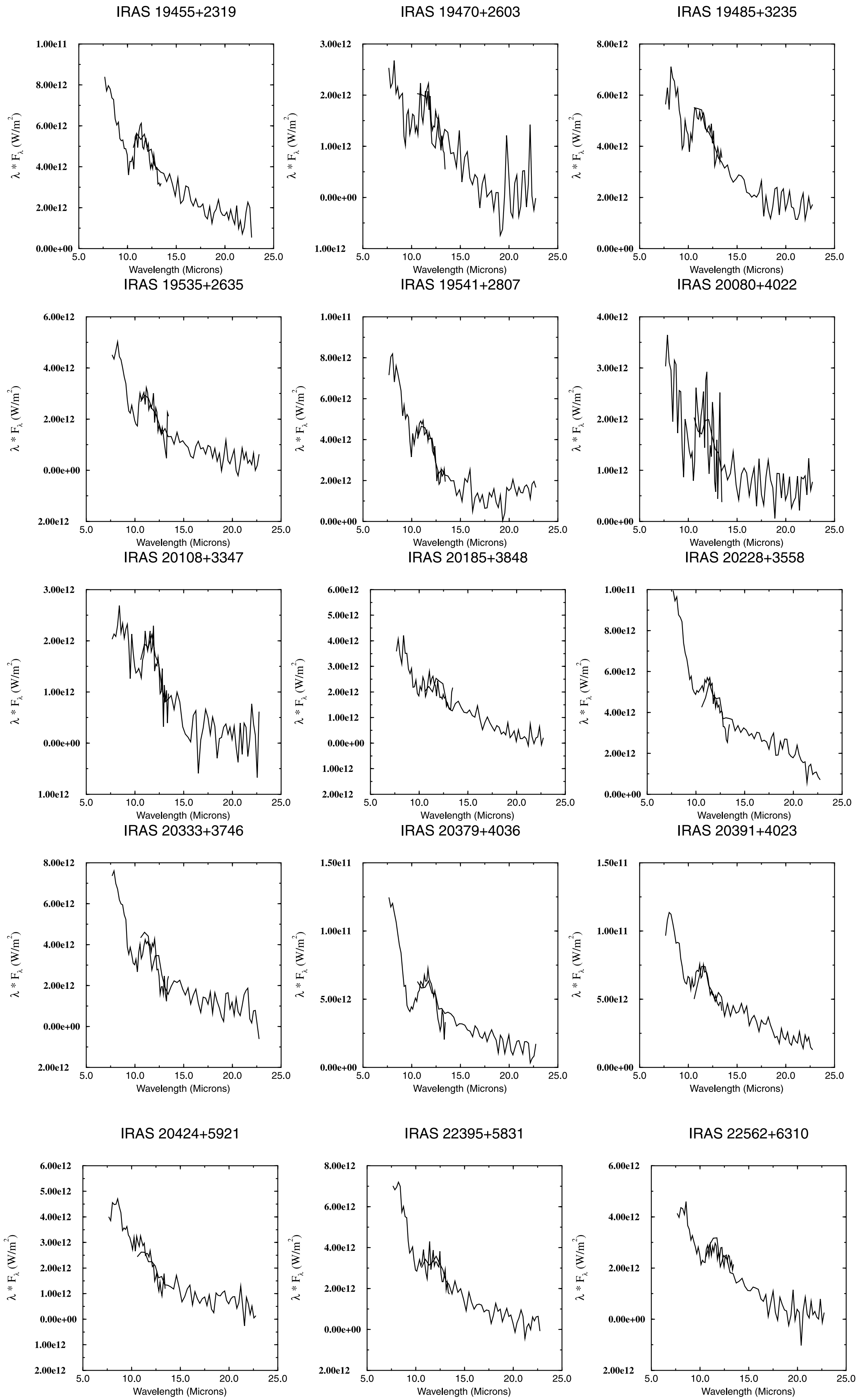

FIG. 2.—*Continued*

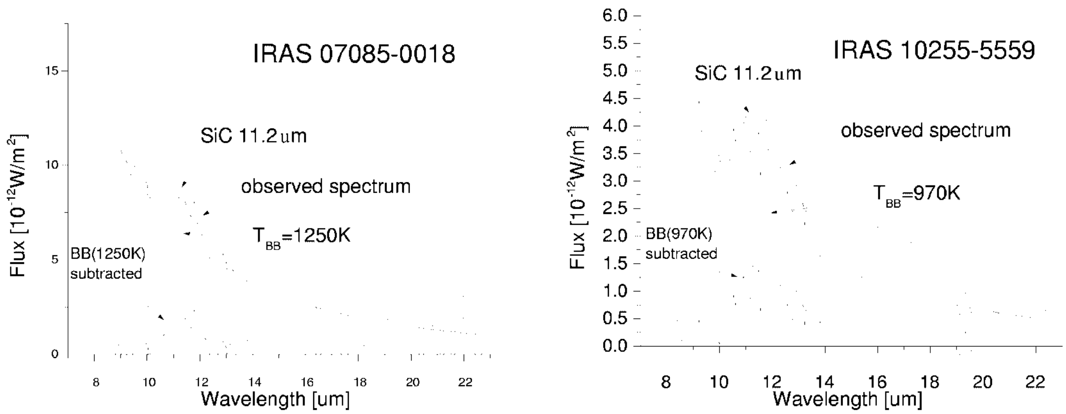

FIG. 3.—Low-resolution spectra of IRAS 07085−0018 and IRAS 10255−5559, each matched to a proper blackbody energy distribution. Excess emission around 11.2 μm is clearly present in both sources.

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