**151. Identification of Spectral Lines in the Violet Region
of Three Carbon Stars HD 156074,
HD 182040, and RU Cam**

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It is very hard to get well exposed spectrograms of late-type carbon stars in the violet spectral region, because the intensity depletion is remarkable shortward beyond $\lambda 4300$. In early-type carbon stars, however, we find the situation much promising. As we hardly find any identification table of spectral lines of carbon stars in this region, it seems to be worth-while to carry out such an identification program.

Fortunately during his stay at the Hale Observatories in 1972 as a guest investigator, the author could measure some coude spectrograms of three carbon stars HD 156074 (C1, 2), HD 182040 (C1, 2), and RU Cam (C0, 1) in the spectral region from $\lambda 3605$ to $\lambda 4350$. Although the wavelength region around H and K lines of Ca was too diffuse to carry on the accurate measurements, the other regions have been well exposed for measuring. The conversion of micrometer readings into wavelengths was carried out at the Computer Center, University of Tokyo. Identification was aided by Revised Multiplet Table (1945), Second Revision of Rowland Preliminary Table of Solar Spectrum Wavelength (1966), and Photometric Atlas of the Solar Spectrum (Utrecht, 1940). Table I gives the list of selected lines which are mostly free from blending. Identified elements in those stars are: Neutral; Mg Al Si Ca Ti V Cr Mn Fe Co Ni. Ionized; Si Sc Ti V Cr Fe Sr Zr Ba La Nd Sm. CN $B^2\Sigma^+ - X^2\Sigma^+$ (0, 1) and (1, 2). CH $A^2\Delta - X^2\Pi$ (0, 0), (1, 1), and (2, 2). In HD 156074 neutral lines of 4th period elements Ca, Ti, V, Cr, Mn, Fe, and Co are enhanced. As for ionized elements, 4th period elements Sc, Ti, V, Cr, Fe, and Si are weak in HD 156074 and rare-earth elements Nd and Sm are enhanced in HD 182040. Molecular band CH is enhanced in HD 156074 and CN is weak in RU Cam.

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Table I

HD 156074 λ (measured)	Int.	HD 182040 λ (measured)	Int.	RU Cam λ (measured)	Int.	Identification	Laboratory λ
3886.20	8	3885.75	7	3885.49	8	Fe 4	3886.28
86.95	8	86.55	7	86.43	8	Fe 20	87.05
88.43	5	87.97	4	87.92	8 (br)	Fe 45	88.52
90.71	3	90.47	2	90.18	7	Fe 280	90.84
95.72	2	95.14	5	94.95	8	Fe 4	95.66
97.24	4	96.93	2	96.78	8	Fe 429	97.45
3902.88	8	3902.52	6	3902.36	8	Fe 45	3902.95
04.66	2	04.41	1	04.08	7	Ti 56	04.79
05.34	7	05.05	5	04.93	8	Si 3	05.53
06.36	8	05.95	5	05.70	8	Fe 4	06.48
09.70	4	09.35	3	09.24	8	Fe 364	09.83
10.62	2	10.42	2	10.18	6	Fe 284	10.85
13.40	5	12.90	5	12.87	7	TiII 34	13.46
20.16	6	19.69	3	19.48	6	Fe 4	20.26
20.98	4	20.54	1	20.59	6	Cr 23	21.02
22.79	8	22.34	3	22.21	6	Fe 4	22.91
47.49	3	47.01	2	46.95	5	Fe 361, 426	47.53
48.04	2	47.57	2	47.54	5	Fe 562	48.11
51.04	3	50.63	3	50.39	6	Fe 661 Cr 136	51.16
53.78	0	53.32	2	53.16	1	Fe 362	53.86
55.14	2	54.74	3	54.69	7	Fe 562	55.35
55.68	1	55.41	3	55.48	9	Fe 488	55.96
61.36	8	61.07	3	60.90	6	Al 1	61.52
66.15	3	65.70	5	65.55	5	Fe 45	66.07
77.62	6	77.25	2	77.06	7	Fe 72	77.74
78.42	5	78.02	2	77.90	7	Fe 361	78.47
80.89	2	80.57	2	80.32	2	Fe 122	81.11
85.21	5	84.86	2	84.62	6	Fe 661	85.39
86.04	5	85.69	2	85.48	6	Fe 655	86.18
88.39	4	87.99	4	87.85	6	LaII 40	88.51
88.94	4	88.55	3	88.42	6	ScII 8	89.06
90.99	2	90.67	3	90.52	4	Cr 38 ZrII 30	91.12
95.95	2	95.37	2	95.30	7	Fe 279	96.00
98.52	7	98.12	5	98.10	8	Ti 12	98.64
98.98	3	98.60	6	98.46	8	ZrII 16	98.98
4000.25	6	99.85	7	99.72	8	Fe 426, 556	4000.47
01.48	4	4001.06	3	4000.95	4	Fe 72	01.67
01.90	1	01.57	3	01.38	4	FeII 29	02.07
02.87	3	02.42	5	02.23	6	VII 9	02.94
05.55	1	05.15	7	04.97	9	VII 32	05.71
07.13	3	06.85	4	06.73	5	Fe 277	07.28
11.26	2	11.02	2	10.77	2	Fe 218	11.42
12.26	7	11.88	10	11.71	8	TiII 11 CeII 206	12.37
14.44	4	14.00	0	13.85	8	Fe 902 ScII 8	14.53
16.26	3	16.00	0	15.83	1	Fe 560	16.43
17.01	4	16.62	2	16.61	5	Fe 279, 527	17.10
18.02	8	17.71	6	17.57	8	Mn 5	18.10
20.79	6	20.41	2	20.20	3	Co 16	20.90
23.20	1	22.98	1	22.72	6	VII 32	23.39
25.02	4	24.66	7	24.53	7	TiII 11 Ni 240	25.14
28.27	3	27.94	7	27.64	7	TiII 87	28.38
30.55	8	30.23	8	30.11	9	Mn 2	30.76
31.10	2	30.91	6	30.73	5	Fe 486	31.24
32.96	8	32.54	7	32.40	8	Mn 2	33.07
34.36	8	34.00	7	33.81	8	Mn 2 CH(0,0)P17	34.49
36.59	1	36.18	2	36.02	1	VII 9 CH(1,1)R1	36.78
40.53	7	40.19	7	40.08	7	Fe 655	40.65
44.47	7	44.05	5	43.98	5	Fe 359	44.61
45.67	10	45.29	9	45.21	10	Fe 43	45.82
48.59	6	48.17	7	48.00	7	Mn 5 ZrII 43	48.76
49.20	4	48.92	3	48.84	4	Fe 218	49.34
50.19	3	49.76	2	49.82	4	ZrII 43	50.32
51.00	4	50.61	7	50.41	5	VII 32	51.05
51.76	4	51.48	6	51.33	5	CrII 19 Fe 700	51.92
54.76	6	54.39	5	54.24	7	Fe 698	54.83
55.43	6	55.01	5	54.88	6	Mn 5	55.54
57.32	6	56.97	6	56.84	7	Mg 16 Fe 277	57.51
60.97	2	60.63	5	60.45	4	NdII 10	61.09
61.71	2	61.37	3	61.19	0	Mn 29	61.74
62.41	7	62.05	6	61.83	4	Fe 359	62.45
63.48	10	63.07	9	62.87	9	Fe 43	63.60
65.17	5	64.85	4	64.60	4	Fe 698	65.40
66.88	5	66.53	3	66.52	5	Fe 358	66.98
67.87	6	67.59	4	67.33	3	Fe 559	67.98
68.97	5	68.63	4	68.37	2	Fe 557	69.08
70.12	5	69.78	1	69.57	1	Mn 5	70.28
70.68	6	70.44	7	70.22	5	Fe 558	70.77
71.57	10	71.14	9	71.06	8	Fe 43	71.74
74.63	7	74.20	5	74.09	5	Fe 524	74.79
77.65	8	77.23	9	77.11	8	SrII 1	77.71

Table I (Continued)

HD 156074 λ (measured)	Int.	HD 182040 λ (measured)	Int.	RU Cam λ (measured)	Int.	Identification	Laboratory λ
4079.20	8	4078.77	8	4078.64	5	Mn 5	4079.24 .42
79.72	6	79.30	5	79.14	3	Fe 359	79.85
80.07	6	79.79	4	79.57	4	Fe 558	80.23
82.14	5	81.80	7	81.59	4 (br)	Fe 698	82.13
82.91	6	82.54	7	82.41	5	Mn 5	82.94
84.35	5	83.97	6	83.89	3	Fe 698	84.50
85.23	5	84.78	5	84.58	5	Fe 559 CeII 172	85.31 .23
86.54	2	86.14	5	86.00	3	LaII 10	86.72
86.97	1	86.64	5	86.45	3	Fe 694	87.10
89.97	6	89.69	4	89.42	2	Fe 700	90.09
90.68	4	90.34	4	90.27	2	Fe 695	90.98
91.41	3	91.03	4	90.89	0	Fe 357	91.56
92.30	8	91.88	7	91.90	6 (br)	Co 29	92.39
95.89	7	95.49	7	95.30	5	Fe 217	95.98
98.04	4	97.64	5	97.68	3	Fe 558	98.18
98.94	7	98.47	7	98.36	3	Fe 600, 651	99.08
99.74	5	99.37	6	99.33	2	V 27	99.80
4100.56	7	4100.19	7	99.96	3	Fe 18	4100.75
01.24	5	00.98	7	4100.73	3	Fe 698	01.27
01.96	0	01.57	6	01.53	2	V 41	02.16
02.62	5	02.23	7	02.12	2	Si 2 Ni 255P	02.93 .74
03.38	5	02.94	7	02.82	1	CN(1,2)R58	03.46
04.77	7 (br)	04.48	7	04.24	5	Fe 694	04.97
06.31	7	06.00	8	05.78	5	Fe 697	06.44
07.42	6	06.88	8	06.83	5	Fe 354	07.49
07.99	5	07.65	7	07.61	4	Fe 559	08.13
08.94	4	08.65	7	08.47	4	Fe 558	09.07
10.43	8	10.06	7 (br)	09.95	3	Co 29	10.53
11.39	7	10.93	7	10.75	1	Cr 97	11.36
11.71	7	11.23	7	11.11	2	V 27	11.79
12.95	7	12.56	7	12.38	3	Fe 1103	12.97
14.49	7	14.03	6	13.82	3	Fe 357	14.45
15.06	6	14.74	5	14.51	2	V 27	15.19
16.36	6	16.05	5	15.80	3	V 27	16.47
17.61	7	17.23	3	17.14	3	Fe 700, 1103	17.87
21.04	4	20.76	2	20.61	5	Co 28	21.32
21.66	2	21.25	1	21.13	1	Fe 356	21.81
23.55	4	23.22	1	23.12	6	Fe 217, 422	23.75
25.82	7	25.50	6	25.35	6 (br)	Fe 354	25.88
28.59	1	28.17	1	28.08	4	FeII 27	28.74
30.05	7	29.64	6	29.51	5	Fe 44, 486	30.04
30.58	6	30.13	4	30.13	7 (br)	BaII 4	30.65
31.86	9	31.41	7	31.35	8 (br)	Fe 43	32.06
36.41	6	35.99	2	35.85	2	Fe 694	36.51
37.07	7	36.65	3	36.60	3	Fe 726	37.00
43.41	4	42.90	2	42.76	4	Fe 523	43.42
43.78	7	43.37	3	43.23	5 (d)	Fe 43	43.87
45.87	4	45.43	3	45.24	5	Fe 422	46.07
47.57	5	47.12	1	47.02	5	Fe 42	47.67
48.52	3	48.08	2	47.91	1	Cr 241	48.52
49.09	2	48.64	1	48.57	2	ZrII 41	49.22
52.19	5	51.64	2	51.49	5	Fe 18	52.17
53.78	3	53.33	3	53.24	3	Fe 695	53.91
54.53	6	54.11	3	53.96	5	Fe 355	54.50
55.22	2	54.77	2	54.67	1	SmII 8, 50	55.22
56.70	2	56.26	4	56.16	5	Fe 354	56.80
58.62	2	58.23	4	58.28	3	Fe 695	58.80
62.43	5	62.02	7 (br)	61.90	3	CH(0,0)R25	62.46 .66
63.34	6	62.95	7	62.88	7	TiII 105	63.64
63.93	5	63.61	6	63.39	7	VII 37	64.02
65.99	5	65.62	5	65.45	4	BaII 4	66.00
67.18	6	66.71	7	66.70	6	Mg 15	67.26
68.48	6	68.05	8	67.93	2	Fe 689	68.63
73.30	7	72.96	5	72.86	5	FeII 27	73.45
74.80	8	74.35	3	74.33	3	Fe 19	74.92
80.69	7	80.30	7	80.19	2	CH(0,0)R21	80.81
83.26	6	82.97	6	82.92	3	VII 87	83.44
84.10	6	83.64	8	83.56	3	TiII 21	84.33
84.80	7	84.40	7	84.24	3	Fe 355	84.90
86.94	7	86.58	6	86.42	2	Fe 152	87.04
87.64	8	87.24	8	87.15	2	Fe 152	87.80
89.30	7	88.96	7	88.85	1	Fe 940	89.56
89.99	8	89.59	7	89.40	2	Cr 84	90.16
90.66	6	90.28	5	90.07	1	Co 1	90.71
92.32	7	91.90	6	91.78	1	CH(0,0)R19	92.57
94.14	2	93.77	4	93.61	1	CN(1,2)P9 P37	94.24
94.64	7	94.31	4	94.12	3	CH(0,0)R19	94.85
96.34	7	96.00	6	95.96	6	Fe 418	96.53
98.05	8	97.59	7	97.63	6	Fe 152, 693	98.31 .27
99.00	6	98.61	7	98.46	5	Fe 522	99.10

Table I (Continued)

HD 156074 λ (measured)	Int.	HD 182040 λ (measured)	Int.	RU Cam λ (measured)	Int.	Identification	Laboratory λ
4199.86	7	4199.37	6	4199.32	4	Fe 3	4199.97
4201.94	9	4201.44	6	4201.34	7	Fe 42	4202.03
03.76	6	03.56	6	03.30	3	Fe 355	03.99
05.91	5	05.51	4	05.25	0	CN(0,1)P48	05.89 .96
06.46	7	06.18	5	05.97	2	Fe 3 CH(0,0)R17	06.70 .58
08.09	6	07.57	4	07.49	1	CH(0,1)P45	08.10 .17
09.43	6	08.98	4	08.87	1	CH(1,1)R19	09.50 .60
11.12	7	10.64	4	10.59	1	Cr 133	11.35
11.66	7	11.22	5	11.15	1	Ti 279	11.73
12.19	6	11.68	4	11.68	0	CN(0,1)P38	12.23
13.46	5	13.01	2	13.04	2	Fe 355	13.65
14.95	6	14.70	10	14.50	8	CN(0,1)P15 P30	15.17
22.10	4	21.78	6	21.62	3	Fe 152	22.22
24.04	3	23.67	5	23.57	3	Fe 689	24.18
25.22	6	24.78	7	24.62	4	VII 37	25.23
26.55	10	26.11	10	26.03	8	Ca 2	26.73
33.89	2	33.57	1	33.51	2	V 6, 111	34.00
35.05	6	34.65	7	34.55	3	Mn 23	35.14
35.75	9	35.31	9	35.31	9	Fe 152	35.94
38.71	5	38.29	4	38.22	3	Fe 693	38.82
40.24	2	39.89	2	39.84	1	Fe 764	40.37
43.33	6	42.84	3	42.70	4	CH(0,0)R11	43.37
45.16	7	44.72	5	44.60	3	Fe 352	45.26
45.89	6	45.43	5	45.38	3	Fe 906	46.09
46.72	6	46.28	9	46.19	5	ScII 7	46.83
47.30	6	46.82	5	46.74	7	Fe 693	47.43
48.18	5	47.71	5	47.67	4	Fe 482	48.23
48.73	3	48.18	1	48.06	4	CH(0,0)R10	48.73 .94
49.40	5	48.88	1	48.88	2	CH(0,0)R10	49.72 .64
50.00	7	49.58	7	49.49	6	Fe 152	50.13
50.67	8	50.22	9	50.16	6	Fe 42	50.79
54.20	6	53.84	6	53.71	4	Cr 1	54.35
58.17	8	57.69	7	57.63	7	Fe 3	58.32
62.54	1	62.08	1	61.95	0	CH(2,2)R12	62.59 .71
64.10	1	63.73	1	63.57	1	Fe 692	64.21
67.76	4	67.30	5	67.30	5	Fe 482 CH(0,0)R7	67.83 .75
68.62	2	68.24	6	68.24	3	Fe 649	68.74
70.08	1	69.65	1	69.46	2	Ti 251 CH(1,1)R7	70.17
71.10	9	70.58	6	70.60	7	Fe 152	71.16
71.65	10	71.22	9	71.16	7	Fe 42	71.76
74.69	7	74.25	6	74.20	6	Cr 1	74.80
78.76	1	78.27	0	78.29	1	CH(0,0)Q25	78.85
79.68	5(br)	79.29	2	79.17	6	CH(0,0)R5 Q23	79.72
80.86	5	80.41	1	80.39	6	CH(0,0)Q24 (1,1)R5	80.96
82.33	6	81.82	6	81.85	7	Fe 71	82.41
82.83	5	82.49	4	82.43	6	Ca 5	83.01
84.11	4	83.59	2	83.73	3	CH(0,0)Q21	84.23
87.74	7	87.31	8	87.33	5	TiII 20	87.89
89.18	3	88.78	2	88.75	3	Ca 5	89.36
89.62	7	89.25	5	89.00	4	Cr 1	89.72
90.10	6	89.70	7	89.59	5	TiII 41	90.22
90.79	6	90.38	4	90.34	3	Ti 44 Fe 351	90.93 .87
91.37	6	90.89	2	90.74	3	Fe 3, 41	91.47
92.95	4	92.57	2	92.59	3	CH(0,0)Q18 Q17	93.04 .11
94.00	9	93.51	9	93.35	8	Fe 41	94.13
94.78	3	94.30	7	94.09	8	SiII 15	94.77
99.90	6	99.49	6	99.28	5	TiII 41	4300.05
4300.41	5	4300.01	1	99.87	8	Ti 44	00.57
02.50	5	01.91	5	4301.87	5	Ca 5	02.53
03.03	4	02.65	7	02.43	5	FeII 27	03.17
07.77	10	07.32	9	07.50	8	Fe 42	07.91
09.39	3	08.94	8	08.82	3	Fe 4, 14	09.38
12.68	5	12.30	8	12.08	5	TiII 41 CH(0,0)Q4	12.86
14.01	8	13.59	9	13.40	6	ScII 15	14.08
16.78	1	16.25	2	16.21	2	TiII 94	16.81
17.32	0	16.75	2	16.59	2	ZrII 40	17.32
18.57	5	18.14	6	18.03	4	Ca 5	18.65
20.68	6	20.25	8	20.10	7(br)	ScII 15	20.75
24.87	4	24.40	5	24.20	7	ScII 15	25.01
25.66	9	25.19	8	24.91	9	Fe 42	25.77
30.21	1	29.69	6	29.71	4(br)	TiII 94	30.26
31.53	1	31.25	5	30.93	2	Ni 52	31.65
33.69	1	33.19	2	33.17	2	LaII 24	33.76
36.97	6	36.47	5	36.42	6	Fe 41	37.05
39.36	5	38.98	5	38.74	5	Cr 22	39.45
44.25	3	43.81	8	43.63	5	TiII 20	44.29
46.44	2	46.01	3	45.81	1	Fe 598	46.56
47.75	2	47.23	3	47.15	1	Fe 828	47.85

In case of two contributors, the preceding element is the dominant one.

HD 156074: Ce 12737, Ce 8062

HD 182040: Ce 3103

RU Cam: Pc 2919