THE FAR UV SPECTRUM OF THE O4V((f)) STAR 9 SAGITTARII

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Abstract. A detailed list of line identifications of the far UV spectrum of the O4V((f)) star 9 Sagittarii (HD 164794) in the wavelength range $\lambda\lambda$1174–2000 Å is presented. The identification is based on two spectra recorded in 1981 (on 16 April – SWP 13729 and on 24 August – SWP 14805) by the International Ultraviolet Explorer (IUE). In the list many unclassified lines are included. The radial velocities of all lines, classified and unclassified, are measured for both spectra and the mean velocities for different ions are discussed.

1. Introduction

9 Sgr is one of the brightest Of stars assigned by Walborn (1971) the spectral type O4V((f)). Conti and Leep (1974) classified it as O4((f)), while Morton (1969), Peterson and Scholz (1971), and Auer and Mihalas (1972) retained the historic type of O5.

The visual spectrum was described by Peterson and Scholz (1971) and Scholz (1972). The main physical characteristics of the star were summarized by de Jager (1980). Peterson and Scholz (1971) from visual spectra derived $T_{\text{eff}} = 54\,000$ K and $\log g = 4.4$ from the O III/O IV ionization equilibrium and hydrogen lines using LTE model atmospheres. Auer and Mihalas (1972) obtained T_{eff} greater than 50 000 K and $\log g$ about 4.0 from hydrogen and helium lines computed in non-LTE. These temperatures are supported by Hα flux measurements from the nebula NGC 6523 yielding $T_{\text{eff}} = 49\,900$ K, whereas radio fluxes yield a somewhat lower value of 42 000 K (Morton, 1969). Baschek and Scholz (1971) found that the absorption spectrum of 9 Sgr is similar to that of ζ Puppis and that ζ Puppis is somewhat cooler than 9 Sgr; the emission lines are, in general, substantially stronger in ζ Pup than in 9 Sgr.

In this paper we give a finding list, as complete as possible, of all the far UV lines ($\lambda\lambda$1174–2000 Å) of 9 Sgr with certain or probable identification. In this finding list many unclassified lines are included. The identification is based on two IUE spectra recorded in 1981 on 14 April and 24 August (SWP 13729 and SWP 14805, respectively). The radial velocities of all these lines were measured for both spectra in the above region. Unfortunately 9 Sgr, like most other O-type stars, has relatively wide photospheric lines, so that most of the features are blended. Nevertheless, it is important to have an uncertain identification than no identification at all for such a hot star in the high-resolution survey from IUE. Since the identification for many unclassified lines could be proved wrong in the future the mean radial velocities for different ions were discussed instead of the radial velocities of individual lines.

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2. Observational Data

The high-resolution far UV spectra of 9 Sgr ($\lambda\lambda$1174–2000 Å) analysed in this paper were obtained on 16 April and 24 August, 1981, with the International Ultraviolet Explorer satellite by Drs R. Costero (SWP 13729) and R. Stalio (SWP 14085), respectively. The line-identifications were performed on the basis of the multiplet tables of Moore (1968) and Kelly (1979).

The finding list for the identified lines of 9 Sgr is given in Table I. The successive columns in this table give:

(1) The measured wavelength in Å for the principal ions for the spectrum SWP 13729.
(2) The respective radial velocity in km s^{-1}.
(3) The measured wavelength in Å for the principal ions for the spectrum SWP 14805.
(4) The respective radial velocity in km s^{-1}.
(5) The identification of the possible ions contributing to the formation of the line.
(6) The multiplet number from Kelly (1979). If a multiplet number is not given the line is unclassified.
(7) The laboratory wavelength of the possible ions in Å from the same source.
(8) The intensity of the line from Kelly (1979). If intensity is not given the line is unclassified.
(9) Remarks giving information on the possible blends.
(10) The excitation potential χ in eV.

The precision of the observed line position is limited by the IUE resolution (± 0.1 Å and more) and by the severe blending due to the crowding of the lines. The study of interstellar lines (Morton, 1976) indicates a line-shift of -0.30 Å (SWP 13729) and $+0.10$ Å (SWP 14805). The values of radial velocity different lines given in columns 2 and 4 of Table I have already been corrected of this line-shift.

Table II presents the average radial velocities of all the lines with reasonable identification in the two spectra of 9 Sgr. In this table the first column gives the ion, the second the low-ionization potential in eV, the third the average radial velocity in km s^{-1} for the lines of the SWP 13729 spectrum (16 April, 1981) and the fourth column the standard deviation (σ) in km s^{-1}. The next three columns give the total number of lines of this particular ion identified in this spectrum (Tt), the number of classified lines among them (Cl), and the number of lines finally included in the average (In) since some of the identified lines presented radial velocity exceeding 1.6σ the average value of the velocity. The next five columns give the same information (average radial velocity and σ in km s^{-1}, the total number of lines, the number of classified lines and the number of the lines included in the average) but for the other spectrum SWP 14805 (24 August, 1981).

Figure 1 gives the average radial velocities in km s^{-1} versus the ionization potential i.p. in eV with error bars in the radial velocity from Table II for the two spectra. Dots represent radial velocities for SWP 13729 and open circles for SWP 14805. The two spectra are almost identical (of course with different values since the two spectra present a difference of almost 44 km s^{-1} in the average radial velocity).

TABLE I

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spectrum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1174.75	+29	1174.90	-33	C III	4	1174.933	800	]	6.46
1175.05	+22	1175.20	-41	C III	4	1175.263	700	]	6.47
1175.25	-11	1175.60	-22	C III	4	1175.590	600	blend	6.46
1175.50	+22			C III	4	1175.711	1000	]	6.47
1175.60	+ 3	1175.90	-47	C III	4	1175.987	700	]	6.46
1176.10	+ 7	1176.40	-17	C III	4	1176.370	800	]	6.47
1182.85	+30	1183.10	- 7	N III	20	1183.030	350		18.01
1184.30	+14	1184.70	+14	N III	20	1184.544	400		18.02
1187.90	+49	1188.30	+49	N IV	18.49	1188.006	300		
1194.30	+26	1194.50	-25	Si II	5	1194.5001	250		0.04
1206.10		1206.45		?					
1206.35	+33	1206.50	-26	Si III	2	1206.510	600	blend Si III [11] in	
1207.30	+19	1207.50	-28	Si III	22	1207.517	180	wing of L α	15.15
				Cr IV		1207.567	100		
1210.25	+22	1210.35	-50	Si III	21	1210.456	200		15.15
1210.85	+38	1211.00	-22	Mg IV		1210.993	300	L α	
1213.40	+97	1213.40	0	Ca III		1213.301	300		
1214.85	+14	1215.10	-21	He II	13	1215.088P	143		40.64
1215.15	+26	1215.40	- 9	D I	1	1215.339P	1000		0.00
1219.20	+107	1219.25	+33	Mg IV		1219.019	150		
1220.60	- 5	1220.65	-93	Mg IV		1220.929	200		
1222.10	+19	1222.15	-107	Mn IV		1222.489	200		2.84
1225.10	+50	1225.15	-34	N IV	18.76	1225.192	150		
1225.60	+44	1225.65		N IV	18.76	1225.719	200		
1229.80	+13	1230.00	-35	C IV	11.14	1230.046	100		39.68
1230.35	+34			C IV	11.14	1230.511	150		39.68
1230.55	+13	1230.70	-47	Si IV	20	1230.795P	-	N V [1]	27.06
1230.85	+43	1231.05	- 6	Ca III		1230.975	400		
1235.35	+ 5	1235.35	-92	Si III	49	1235.431	140		19.02
1236.90	+54	1237.00	-19	Mg IV		1236.979	200		
				N V	1	1238.82	1000		
1240.00	+79	1240.20	+30	Ca III		1239.976	400		
				N V	1	1242.80	800		
1244.15	+30	-		Mn IV		1244.327P	900		
1246.30	+22	1246.50	-26	N IV	18.92	1246.51	100		
1246.45	+ 4	1246.70	-33	Si II	8	1246.738	100		5.33
1247.10	+ 5	1247.25	-56	C III	9	1247.383	600		12.64
1247.40	- 5	1247.60	-54	Mn IV		1247.726	850		
1248.30	+43	1248.50	- 6	Si II	8	1248.426	150		5.32
1248.65	+76	-		Mn IV		1248.638	300		
1251.75	+26	1251.95	-19	Mn IV		1251.933	950		
1252.60	+40	1252.85	+ 4	Mn IV		1252.736P	450		
1253.30	+34	1253.40	-39	Ca III		1253.464	300		
1254.70	- 8	1255.00	-30	Ne III	13	1255.03	200		39.44
1255.55	+39	1255.70	-18	Ne III	13	1255.68	500		39.44
1257.50	+51	1257.80	+19	Al IV		1257.58	150		
1258.10	+63	1258.00	-54	Mn IV		1258.131	750		
1260.20	+17	1260.40	-28	Si II	4	1260.4212	500		0.00
1264.30	+42	1264.40	-27	Mn IV		1264.417	400		
				Ni V		1264.46	200		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1270.00	+ 4	1270.40	+ 5	N IV	18.75	1270.280	250	]	
1271.85	- 3	1272.05	-49	N IV	18.75	1272.160	200	]	
1272.40	-10	1272.65	-44	N IV	18.75	1272.74	150	] blend	
1273.15	- 5	1273.20	-87	N IV	18.75	1273.47	100	]	
1273.45	+ 7	1273.60	-50	N IV	18.75	1273.716	100	]	
1281.45	+46	1281.60	-12	Ca III		1281.553	500		
1283.90	- 4	1284.20	-27	N IV	18.87	1284.218	150		
1285.50	-25	1285.60	-95	Ca III		1285.908	400		
1286.10	+ 8	1286.25	-50	S IV		1286.365	100		
1286.70	111	1286.75	+30	Ca III		1285.523	600		
1287.95	+52			Ca III		1288.029	100		
1293.40	+31	1293.50	-39	Mn V(-)		1293.93	150		
1294.20	- 9	1294.40	-56	Si III	4	1294.543	340	] blend	6.54
1296.05	+ 5	1296.40	- 7	C III	12.07	1296.33	200	]	33.48
1296.35	-17	1296.80	- 6	Si III	4	1296.726	280	]	6.54
				N IV	18.86	1296.600	250	] blend	
1298.75	+37	1298.90	-21	Si III		1298.891	300	]	
				Si III	4	1298.960	360		6.58
1300.65	- 6	1300.80	-61	Ni V		1300.97	50	] blend	
1300.80	-12	1300.95	-67	Si III	4	1301.146	280	]	6.55
1303.10	+17			Si III	4	1302.320	320	] blend	6.58
1303.55	+59	1303.70	+ 3	Fe V		1303.59	100	]	
1306.30	+ 1	1306.50	- 1	Ni V		1306.60	100	]	
1307.70	+14	1307.90	-30	Mg IV		1307.934	100	]	
1308.50	+15	1308.65	-40	C III	11.44	1308.70	200		22.63
1309.60	+ 6	1309.80	-38	N IV	18.55	1309.557	200		
1311.40	+ 1	-		Mg IV		1311.693	200		
1312.30	+13	1312.40	-54	Si III	10	1312.540	260		10.28
1314.45	- 3	1314.75	-24	Ni IV		1314.760	30	?	
1314.80	+22	1314.90	-45	Cr IV		1315.00	100		
1317.40	0	1317.60	-45	Ca III	?	1317.699	550		
1318.40	+52	1318.50	-15	Ni V		1318.47	200	]	
1320.85	+68	1320.90	-11	Cr IV		1320.85	40	]	
1323.80	+44	1324.10	+22	C II	11	1323.9059	300	]	9.29
				C II	11	1323.9513	450	]	9.29
				N IV	18.81	1323.98	1000	]	
				C II	11	1323.9955	30	]	9.29
1324.70	+32	1324.85	-24	Ni IV		1324.859	100	]	
1325.40	+ 4	1325.50	-64	N IV	18.81	1325.685	50	] blend	
1325.70	+32	1325.80	-36	Cr IV		1325.86P	50	]	
1332.35	+48	1332.50	- 8	Cr IV		1332.44P	250		
1334.30	+16	1334.50	-29	C II	1	1334.5323	800		0.00
1335.50	+21	1335.75	-12	C II	1	1335.7077	1000		0.01
1335.80	- 5	1336.05	-38	Mn IV		1336.123	450		
1337.45	+10			P III		1337.71	150	]	
				Ni IV		1337.737	100	]	
1337.70	-13	1337.90	-58	Mn IV		1338.061	350	]	
1338.45	+32	1338.50	-47	O IV		1338.612	200	]	
1338.75	- 4	1338.95	-49	Ni IV		1339.071	740	] blend	
1339.70	+37	1339.95	+ 3	Cr IV		1339.84P	50	]	
1340.20	-25	1340.25	-104	Mn IV		1340.617	250	]	

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1342.85	+36	-		O IV		1342.992	120		
1343.30	+48	1343.50	+ 3	Si III	39	1343.388	120		17.72
1343.65	+99	1343.80	+42	O IV		1343.512	275	blend	
1345.60	+42	1345.80	- 4	Ni IV		1345.718	760		
1346.40	+29	1346.65	- 5	Mg IV		1346.573	800		
1346.50	+28	1346.80	+ 5	Mg IV		1346.680	300	blend	
1346.80	+23	1346.95	-33	P III		1347.000	200A		
1348.75	-12	1348.95	-58	P III		1349.11	200A	blend	
1349.80	+ 8	1350.00	-34	Si II	7	1350.057	150		5.34
1351.30	-13	1351.50	-55	Mg IV		1351.652	100		
1351.70	-12	1351.80	-76	Mg IV		1352.049	600		
1352.50	+46	1352.60	-18	Si II		1352.585	217		
1353.65	+50	1353.70	-25	Si II	7	1353.718	100		5.34
1356.10	+70	1356.35	+39	Ni IV		1356.078	450		
1356.40	-97	1356.90	-73	Ni IV		1357.063	760		
1356.90	+13	1356.90	- 7	Fe V		1357.1357	100		
1358.55	+55	1358.70	+ 2	Mn IV		1358.594	450		
1359.05	-14	1359.45	-23	Fe V		1359.41	100		
1361.25	+28	1361.35	-36	Fe V		1361.42	500		
1361.45	+33	1361.70	+ 2	Si III	46	1361.597	160		19.02
1361.90	-38	1362.10	-80	Si III	38	1362.366	100		17.72
1362.90	+43	1363.10	+ 1	Fe V		1363.00	400	blended	
				Ni IV		1363.258	560		
1363.65	+50	1363.75	-14	Fe V		1363.72	300	blended	
1364.95	+23	1365.10	-30	Fe V		1365.14	300		
1365.00	0	1365.30	-11	Si III	38	1365.253	160		17.72
1365.30	+10	1365.65	+ 1	Si IV	19	1365.549P			
1371.10	+87	1371.15	+10	Fe V		1371.00	400		
1371.15	+34	1371.30	- 6	O V	7	1371.292	800	blend	
1371.30	-12	1371.60	-32	Si III	67	1371.652	60	C V[7]	21.73
1371.50	+26	1371.80	+ 5	Ni IV		1371.679	580		
1373.40	+ 4	1373.55	-49	Fe V		1373.68	600		
1375.15	+48	1375.15	-38	Mg IV		1375.226	200		
-		1375.50	-34	Cr IV		1375.56	200		
1376.20	+11	1376.50	-10	Fe V		1376.45	600		
1378.40	0	1378.70	-21	Mg III		1378.700	40		
1380.15	- 2	1380.35	-45	P III	7	1380.46	500		9.25
1384.15	+17	1384.40	-14	Fe V		1384.37	100		
				Mg IV		1384.463	900		
1385.40	+82	1385.60	+40	Fe V		1385.32	200	blend	
1385.60	+28	1385.90	+ 7	Mg IV		1385.772	500		
1387.20	- 6	1387.40	-48	Mg IV		1387.527	700		
1388.00	+28	1388.20	-15	Fe V		1388.17	500		
1389.10	-24	1389.45	-35	N V	43	1389.514	50		
1393.05	- 8			Mg III		1393.391	350		
1393.50	+10	1393.70	-23	Si IV	1	1393.755	1000		0.00
1393.90	+38	1394.00	-26	Fe III		1394.024	70		
1394.60	+28	1394.80	-15	Fe V		1394.77	300		
1395.70	+ 4	1395.90	-39	Ni IV		1395.985	480		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1397.75	+51	1397.80	+ 3	Ca III		1397.687	550		
1397.95	+22	1398.15	-21	Fe V		1398.15	300	blend	
				Ni IV		1398.195	780		
1399.40	-15			O IV		1399.774	25		
1400.00	-17	1400.30	-20	Fe V		1400.30	400		
1400.25	+44	1400.50	+14	Cu IV		1400.341	171	blend	
1401.00	+30	1401.25	0	O IV		1401.156	60		
1402.45	+63	1402.50	- 9	Fe V		1402.45	600		
1402.70	+48	1402.80	-14	Si IV	1	1402.770	800		0.00
1403.20	+20	1403.25	-52	Cu IV		1403.4	218		
1404.30	-18	1404.50	-58	Mg IV		1404.68	300		
1404.70	+48	1405.00	+29	S IV		1404.77	70		
1405.00	+27	1405.10	-35	Mg III		1405.17	80		
1406.70	+46	1406.90	+ 6	Fe V		1406.78	700		
1407.20	+23	1407.40	-17	O IV		1407.386	25	?	
1408.65	-52	1409.00	-60	Fe V		1409.19	600		
1409.15	+18			Mg IV		1409.361	1000	blend	
1409.30	+18	1409.55	-11	Fe V		1409.51	700		
1409.50	-11	1409.80	-30	Ni IV		1409.846	640		
1412.30		1412.45		?					
1416.40	-30	-		S IV		1416.84	10	?	
1416.70	+10	1417.00	- 7	S IV		1416.94	30	?	
1417.40	+14	1417.60	-27	O V		1417.633	40		
1417.85	+51	1417.95	-11	O V		1417.908	80		
1418.10	+ 1	1418.35	-29	O V		1418.393	120		
1418.95	+51	1419.10	- 1	O V		1419.009	80		
1419.40	+24	1419.60	-16	Ni IV		1419.583	470		
1420.10	+ 2	1420.35	-28	Fe V		1420.39	300		
1421.05	+26			Ni IV		1421.225	620		
1422.00	+69	1422.20	+29	Cl IV		1421.97	100		
1426.60	+21	1426.75	-31	C III	12.05	1426.80	100		33.48
1427.20	+10	1427.40	-31	Ni IV		1427.453	400		
1427.40	-32	1427.70	-52	C III	11.52	1427.85	300		29.53
1428.00	+27	1428.10	-35	C III	11.52	1428.17	200		32.20
1428.20	0	1428.50	-20	C III	11.52	1428.50	200		29.53
1429.70	-40	1429.95	-70	Ni IV		1430.186	430	blend	
1430.35	+50	1430.40	-22	P III		1430.41	200		
				Ni IV		1430.439	540		
1430.55	+50	1430.60	-22	Fe V		1430.61	800		
1430.90	+39	1431.00	-23	Ni IV		1431.013	370		
1433.35	- 8	1433.60	-39	Si III	66	1433.690	120		21.74
1434.45	-29	1434.55	-92	Mg IV		1434.892	150		
1435.60	+26	1435.90	+ 6	Si III	61	1435.776	322		20.55
				Ni IV		1435.792	100		
1435.95	+18	1436.20	-13	Si III	52	1436.166	140		19.72
1436.25	+37	1436.45	- 4	Cu IV		1436.375	117		
1436.45	+ 6	1436.75	-15	Si III	66	1436.724	80		21.73
1437.30	+15	1437.40	-47	Mg IV		1437.53	500		
				Mg IV		1437.636	1000	blend	
1438.35	+59	1438.60	+28	N IV		1438.37	150		
1439.25	+34	1439.30	-39	Si III	66	1439.391	40		21.73
1440.15	+27	-		Mn IV		1440.324	70		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1441.40	- 6	1441.50	-68	Si III	3.05	1441.732	100		6.58
1441.65	+30			Al IV		1441.81	50d		
1442.35	- 5			Ni IV		1442.675	170		
1443.85	+16			Mn IV		1444.078	100		
1445.80	- 2			N IV	18.85	1446.114	250		
1446.15	+29			Cu IV		1446.315	276		
1446.35	- 8	1446.50	-59	Mn V		1446.69	60	blend	
1447.15	+53	1447.40	+22	Si III	3.05	1447.196	120		6.58
				Mg IV		1447.424	300		
				Al IV		1447.47	100d		
1447.60	- 3	1447.85	-35	P V		1447.92	150		
1448.50	-22	1448.80	-43	Fe V		1448.91	600	blend	
1452.75	+39			Mn IV		1452.893	200		
1454.70	+59	1454.90	+19	Fe V		1454.71	300		
1455.20	-19			Fe V		1455.59	500		
1455.40	+ 9	1455.80	+11	Cu IV		1455.650	207		
1456.95	+ 4	1457.10	-47	Mg IV		1457.229	100		
				Si III	60	1457.253	100		20.55
1457.35	+18	1457.60	-12	Mn IV		1457.560P	80	blend	
1459.40	+16	1459.40	-65	Mg IV		1459.617	400		
				Ca III		1459.787	600		
1459.70	+30	1459.90	-10	Fe V		1459.85	500	well shaped	
1460.60	+ 8	1460.50	-94	Fe V		1460.86	200	blend	
1460.90	+28	1461.00	-33	Ni IV		1461.063	140		
1462.50	+26	1462.70	-14	Fe V		1462.67	300	well shaped	
1463.40	+74	1463.55	+24	Ca III		1463.335	750		
1463.70	+55	1463.90	+15	Fe V		1463.73	600		
1465.10	+18	1465.20	-42	Fe III		1465.309	200h	blend	
1465.20	+27	1465.55	+17	Fe V		1465.37	300		
				Ca III		1465.477	300		
1465.60	+28	-		Fe III		1465.763	200h		
1466.40	+42	1466.60	+ 2	Fe III		1466.492	250h		
1466.75	+80	1466.80	+10	Mg IV		1466.655	100	blend	
				Ti IV	3	1467.35	600		15.89
1468.80	+23	1468.90	-38	Fe III		1468.986	150		
1469.00	+18	1469.20	-22	Ti IV	3	1469.21	300		15.89
1469.60	+ 4	1469.80	-37	Fe III		1469.881	400h	blend	
1470.44	-12	1470.90	+ 1	Mg IV		1470.799	100		
1472.40	?	1472.55	?	?				well shaped	
1477.40	+ 4	1477.60	-36	C III	12.04	1477.68	300		33.48
1479.40	+63	1479.90	+104	Fe V		1479.29	400		
1481.25	+ 9	1481.30	-62	Mg IV		1481.509	400		
1482.90	+23			Mn V		1483.09	160		
1484.60	+ 7	1484.70	-54	Ca III		1484.869	800		
1485.30	+32	1485.50	- 9	Mg IV		1485.446	80		
1489.00	+41	1489.20	0	P IV		1489.10	160		
1489.35	-20	1489.60	-50	Cr V		1489.75	500	blend	
1490.30	+31	1490.40	-30	Mg IV		1490.451	350		
1491.75	+11	1492.00	-20	Mg IV		1491.998	900		
1493.30	- 7	-		Fe III	85	1493.640	600h		10.16

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1496.15	-86	1496.30	-137	Ca III		1496.884	600		
1497.10	- 8	1497.50	- 8	Mg IV		1497.442	20?		
1497.80	+17	1497.90	-44	Cr V		1498.02	700		
1498.00		1498.30	?	?					
1499.60	-43	1499.70	-106	Ni IV		1500.128	300		
1500.20	+53	1500.50	+33	Si III	36	1500.241	240		17.72
1501.30	+11	1501.50	-29	P III	6	1501.55	700	]	9.25
1501.60	+ 9			Si III		1501.870	180	] blend	
1502.20	+45	-		P III	6	1502.27	1000	]	9.25
1503.20	+ 3	-		Ni IV		1503.482	310	]	
1503.35	+11	1503.50	-37	Mn V		1503.59	80	] blend	
1503.85	+29	1504.00	-19	Fe III		1504.002	150	]	
1504.60	+24	1504.80	- 3	P III	6	1504.72	900b		9.25
1504.90	+ 6	1505.10	-32	Fe III		1505.166	650h		
				Ni IV		1505.173	230		
1505.90	+27	1506.15	- 1	Si III	72	1506.060	120		21.88
1506.50	+15	1506.70	-23	O V		1506.72	400w		
1506.80	+44	1507.00	+ 6	Ca III		1506.876	550		
1507.00	+37	1507.20	- 1	Mn V		1507.11	40?		
1507.30	+13	1507.40	-45	Fe III		1507.530	150h		
1508.50	- 9	1508.70	-47	Mg IV		1508.841	250		
1511.30	- 4	1511.50	-42	Fe III		1511.617	300h		
-		1512.60	-45	Ni IV		1512.733	600		
1514.35	+17	1514.70	+ 8	Fe III		1514.563	150		
1515.35	+33	1515.45	-25	Fe III		1515.481	300h		
1516.30	-14	1516.55	-43	Ni IV		1516.671	590		
1516.75	+53	1516.95	+15	Mn V		1516.78	160		
1519.00	+55	1519.10	- 3	Cr V		1519.02	700		
1521.60	+ 2	1521.85	-27	Fe III		1521.891	20h		
1524.00	+11	1524.10	-48	Ni IV		1524.245	280	]	
1524.35	+25	-		Fe III		1524.522	300	]	
1524.70	+67	-		Fe III		1524.658	300	]	
				Fe III		1524.799	70	]	
1524.80	-48	1525.30	-27	Fe III		1525.343	70	]	
1525.20	+36	1525.50	+17	Ni IV		1525.316	710	] blend	
				Fe III		1525.343	70	]	
1525.40	+13	-		Fe III		1525.634	150	]	
1525.60	+19	1525.75	-29	Fe III		1525.801	400	]	
1525.80	+17	1526.05	-12	Fe III		1526.016	150	]	
1527.50	+21	1527.65	-27	Ni IV		1527.693	750	]	
1528.00	+33	1528.40	+38	Mn V		1528.13	120	]	
1528.50	-13	1528.70	-52	Ca III		1528.866	450	]	
1529.35	-22	1529.55	-61	Fe III		1529.764	200	]	
1529.80	-23	1530.15	-33	Fe III		1530.220	150h	]	
1531.20	+41	1531.35	- 8	Fe III	84	1531.293	400h	]	10.12
1531.60	+50	1531.70	- 8	Fe III	84	1531.644	550h	]	10.12
				C III	11.65	1531.83	200	]	32.10
				Fe III	84	1531.864	450h	]	10.12
1532.70	+39	1533.05	+30	Fe V		1532.80	400	]	
1535.00	+72			Ni IV		1534.931	480	]	
1538.55	+43	1538.70	- 6	Fe III	84	1538.632	650h	]	10.16

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1538.90	+54	1538.90	-24	Ni IV		1538.927	610		
1539.05	+34	1539.30	+15	Fe III	84	1539.128	550	blended	10.16
1541.00	+37	1541.35	+27	C III		1541.115P		absorption	
1543.30	+96	1543.50	+57	Ni IV		1543.11	790		
				Fe III		1543.640	400h		
1544.30	+20	1544.55	- 9	Fe V		1544.50	300		
1545.25	+50	1545.25	-28	Ca III		1545.294	1000		
				Ni IV		1545.400	440		
				Fe III		1545.411	200h		
1546.20	+75	1546.40	+35	Fe III		1546.120	550h		
				Ni IV		1546.230	680		
1546.50	-24	1546.80	-44	Fe III		1546.928	250h		
1547.30	- 7	1547.45	-56	Fe III		1547.640	550h		
1547.95	+13	1548.20	-16	C IV	1	1548.185	1000		0.00
1548.35	+78	1548.65	+58	Fe III		1548.251	300h		
1548.35	- 4	1548.65	-24	Ni IV		1548.676	450		
1549.20	+69	1549.30	+10	Cl IV		1549.15	200		
				N V	46	1549.30	85		
1549.85	- 6	1549.95	-64	Ni IV		1550.185	320		
-		1520.20	-18	Fe III	84	1550.196	800h		10.23
				C IV	1	1550.774	950	nice shape	0.00
				Fe III	84	1550.862	550h		10.12
				Fe V		1550.90	200	blended in CIV 1	
1550.95	+31	1551.15	- 6	Fe III		1551.085	150h		
				Fe III		1551.1149	150h		
1551.30	+42	1551.50	+ 5	Fe III	84	1551.377	250h		10.23
1553.00	-25	1553.65	+24	Ni IV		1553.426	690		
				Ni IV		1553.491	590		
1553.80	- 6	1554.10	-24	Cu IV	114	1554.124	90		
1554.30	+63	1554.35	- 4	Fe V		1554.27	100		
1556.15	+71	1556.20	+ 5	Fe III		1556.075	300h		
-		1556.65	+11	Fe III		1556.493	550h		
1557.20	+49	1557.30	- 7	Al IV		1557.24	250d		
1558.15	+40	1558.40	+12	Ni IV		1558.240	560		
				Cu IV		1558.271	312		
1559.10	+13	1559.20	-43	Ni IV		1559.327	440		
1559.30	+53	1559.50	-13	Fe III		1559.463	150h		
-		1559.80	-42	Ni IV		1559.917	640		
1559.80	-15	1560.10	-33	Ni IV		1560.175	690		
1560.80	- 3			Ni IV		1561.113	200		
1564.14	-14	1564.30	-60	Fe III		1564.512	150h		
1564.85	+ 9			Fe III		1565.100	200h		
1568.65	+24	1568.90	- 4	Fe III		1568.820	200h		
1572.50	+17	1572.70	-21	Mg III		1572.712	400		
1576.15	- 6	1576.30	-53	C III	12.03	1576.48	300		33.48
1577.15	+28	1577.25	-29	C III	12.03	1577.30	200		33.48
1577.75	+30			C III	12.03	1577.89	200		33.48
1578.60	+27			Fe III		1578.759	150h		
1579.65	+53	1580.00	+44	Cr IV		1579.67	800	blended	
1582.35	+21	1582.50	-25	Ni IV		1582.531	500		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1583.10	+38	-		Fe III		1583.199	200h		
1584.35	+38	1584.40	-28	O III		1584.45	400	blended	
1585.85	+ 5	1585.85	-71	Ca III		1586.126	650		
1588.00	+82	1588.35	+72	O III		1587.87	400		
1588.75	+19	1589.00	-10	Si III	59	1588.950	40		20.55
1589.95	+46	1590.15	+ 7	O III		1590.01	800		
1590.50	+36	-		O III		1590.61	400		
1592.30	+13	1592.50	-26	Mn IV		1592.536	300		
1593.50	+17	1593.70	-21	Fe III		1593.71	70h		
1594.40	+ 8	1594.70	-11	Mn IV		1594.659	500		
1594.85	+14	1595.30	+22	Mn IV		1595.081	500		
1595.30	+ 1	1595.60	-18	Fe III	119	1595.597	400h		11.00
1595.95	-23	1596.20	-52	O V		1596.375	280		
1596.20	- 3	1596.70	+15	O III		1596.52	150		
1600.40	+29	1600.60	- 9	Mn IV		1600.549	550		
1601.10	+34	1601.10	-40	Fe III	118	1601.211	650h		11.00
				Fe III	118	1601.289	400h		11.00
1601.65	-11	1601.95	-28	Fe III	119	1602.000	300h		11.03
1603.10	+42	1603.30	+ 5	Cr V		1603.17	600		
1603.40	+17	1603.50	-38	Mn IV		1603.604	700		
1605.35	+54	1605.40	-11	Ni IV		1605.357	70		
1606.00	+52	1606.20	+16	Fe III	119	1606.014	200h		11.05
1607.05	+44	1607.25	+ 7	Mg IV		1607.109	300		
1607.55	+23	1607.75	-14	Fe III	118	1607.723	600h		11.03
1611.05	+45	1611.05	-29	Mn IV		1611.105	700		
1611.50	+13	1611.50	-61	Fe III	118	1611.723	450h		11.05
				Fe III	118	1611.763	450h		11.05
1612.50	- 2	1612.65	-48	Fe II	43	1612.802	400		0.23
1613.90	+35	1614.10	- 2	Mn V		1614.01P	120		
1616.15	+27	1616.35	-10	N V	50	1616.30	150w		
1616.80	-14	1616.90	-69	Fe III		1617.171	70		
1619.55	+27	1619.80	0	N V	53	1619.7	250w		
1619.90	+24	1620.25	+14	C III	11.72	1620.07	300		32.20
1620.10	+12	1620.40	- 6	C III	11.72	1620.33	200		32.20
1620.55	+31	1620.70	-15	C III	11.72	1620.68	100	blend	32.20
1628.25	+45	-		Fe III		1628.304	200		
1630.80	+35	1631.05	- 7	Cr V		1630.91	100		
1635.40	- 1	1635.65	-29	Ni IV		1635.707	300		
1638.25	+24	1638.30	-41	Cr V		1638.42	700		
1639.40	+64			Cr V		1639.35	500		
1640.00	- 6	1640.40	- 7	He II	12	1640.332P	333		40.64
1640.55	+69	1640.70	+22	He II	12	1640.474P	600	blend	40.64
				He II	12	1640.490P	70		40.64
1643.35	+46	1643.40	-19	Cl IV		1643.40	100		
1643.80	+77	1643.80	+ 3	O V		1643.68	560w		
1644.10	+73	1644.00	-19	Cr V		1644.00	400		
1644.40	+13	1644.55	-34	Cr IV		1644.63	50		
1644.90	+31	1644.85	-52	C III	11.64	1645.03	100		32.10
1647.40	+28	1647.50	-28	P III		1647.55	300		
1647.70	+42	1647.70	-32	Mn IV		1647.773	300		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1650.55	+49	1650.55	-22	Mn IV		1650.573	300		
1651.05	+24	1650.95	-65	Cl IV		1651.21	100		
1651.60	+38	1651.50	-52	Mn IV		1651.685	350		
1652.30	+13	1652.30	-58	Cr V		1652.52	200		
1653.80	+47	1654.15	+40	Mn IV		1653.833	750		
1654.60	+43	1655.00	+45	Cu IV		1654.655	190		
1658.75	+32	-		Mg IV		1658.868	100		
1659.10	+26	1659.40	+ 9	Mn IV		1659.249	700		
1661.25	+40	-		Mn IV		1661.324	350		
1664.60	+29	1664.70	-24	Mn IV		1664.733	750		
1665.80	-11	-		O III		1666.153	250		
1667.00	+54	1667.15	+10	Mn IV		1667.6288	800wt		
1667.70	+62	1667.90	+27	Mn IV		1667.651	100		
1671.85	+27	1671.85	-44	Mn IV		1671.995	600		
1675.30	+22	1675.40	-30	Mn IV		1675.472	250		
1678.40	-658	1678.70	-82	O III		1679.06	400		
1682.95	+41	1682.90	-31	Mg IV		1683.016	500		
				Mn IV		1683.115	450		
1685.90	+41	1686.00	-12	Mn IV		1685.967	300		
1687.15	+63	1687.40	+37	Mg III		1687.091	250	blended	
1687.70	+32	1687.85	-13	N IV	20	1687.82	100		
1688.20	+69	1688.20	- 2	N IV	20	1688.11	150		
1688.65	+32	1688.85	- 4	Ca III		1688.770	450		
1691.30	-15	1691.50	-51	Mn IV		1691.684	750		
1693.00	+26	1692.95	-53	Mn IV		1693.150	750		
1696.35	+19	1696.50	-25	N III		1696.54	150		
1696.70	+25	1696.90	-11	N IV	18.91	1696.86	150		
				P III		1696.92	100		
1697.20	+39	1697.15	-41	Mg III		1697.282	250		
1698.55	+27	1698.60	-35	Mn IV		1698.695	750		
1699.00	+49	1699.20	+13	Mn IV		1699.062	700		
1699.60	+38	1699.70	-16	Mg IV		1699.686	100		
1699.80	+39	1700.00	+ 4	N III		1699.88P	200		
1702.15	+77	1702.00	-18	N IV	18.91	1702.006	250		
1703.00	+14	1703.00	-55	N V	45	1703.218	60		
1704.90	+16	-		Mn IV		1705.11	100		
1707.75	+10	1708.10	+ 1	O V		1707.996	400		
1710.00	-12	1710.35	+ 3	Fe III		1710.374	200		
1716.50	+13	1716.70	+ 3	V V		1716.722	50		
1717.30	+32	1717.30	-37	Fe III		1717.414	150		
1718.20	+36	1718.50	+20	Mn IV		1718.29	400b		
				N IV	7	1718.55	1000	N IV [7]	
1720.20	+29	1720.25	-32	Ca III		1720.334	300		
1720.55	+57	1720.80	+31	Mn IV		1720.521	750w		
1722.60	+63	1722.85	+38	Si IV	10	1722.534	400		19.88
				Fe III		1722.837	250		
1722.90	+44	1723.15	+19	Mn IV		1722.944	650		
1724.70	+30	1724.90	- 4	Mn IV		1724.827	750		
1727.30	+39	1727.60	+22	Si IV	10	1727.277	300		19.88
1730.00	+45	1730.05	-15	N III		1730.04	400		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1730.50	+43	1730.75	+17	Mn IV		1730.553	600		
1730.80	+45	1731.00	+10	Fe III		1730.842	250		
1731.40	+83	1731.50	+32	Cr IV	14	1731.22	100		12.84
1731.65	-19	1732.00	-27	Mn IV		1731.684	200		
1734.40	+ 4	1734.60	-31	Cr IV		1734.68	60		
1736.10	+52	1736.30	+18	Mg IV		1736.098	70	]	
				Mn IV		1736.516	300	] blend	
1739.15	+40	1739.10	-38	Cr IV	14	1739.22	250		12.87
1739.80	+14	1739.75	-64	Mn IV		1740.022	250		
1742.00	+34	-		Mn IV		1742.105	850w		
1744.20	+52	1744.25	+ 9	Fe III		1744.2	200		
1744.50	+19	1744.55	-24	Mg IV		1744.692	60		
1745.50	+66	1745.70	+48	S IV		1745.42	100		
1747.60	+ 7	1747.85	- 2	N III	19	1747.86	450	] blend	18.01
1747.80	-13	1748.10	-13	Fe III		1748.177	150	]	
1749.05	+52	1749.10	+ 8	Fe III		1749.052	70		
1751.30	+60			N III	19	1751.24	300	]	18.02
1751.50	+35	1751.80	+36	Mn IV		1751.587	850	]	
				N III	19	1751.75	500	] blend	18.02
1754.05	+32	1754.35	+34	Ca III		1754.153	100		
1754.50	+48	1754.70	+32	Cr IV	13	1754.51P	250		12.98
1760.10	+47	1760.20	+14	O III		1760.12	700		
				O III		1760.42	500		
1762.50	+31			Cr IV	13	1762.61P	250		12.92
1763.40	+83	1763.55	+59	F III		1763.206	150		
				O III		1763.22	700		
1764.40	+36			O III		1764.48	700		
1767.15	+61	1767.50	+70	Mn IV		1767.087	750		
1767.70	+36	1767.95	+29	O III		1767.78	1000	]	
1768.30	+60	1768.70	+78	O III		1768.24	900	] blend	
1769.25	+38			O III		1769.32	400		
1770.35	+15	1770.40	-26	Fe III		1770.554	400		
1771.20	+43	1771.30	+ 9	Mn IV		1771.244	450		
1771.55	+30	1771.80	+22	O III		1771.67	900		
1772.30	+48	1772.30	- 2	O III		1772.31	400		
1772.80	+19	1773.00	+ 3	Mg III		1772.982	350		
				O III		1773.00	500		
1773.25	+ 6	-		Mn IV		1773.509	750		
1773.90	+58	-		O III		1773.85	500		
1775.85	+28	1776.00	-14	Fe III		1775.983	400		
1776.65	+60	1776.90	+35	Mn IV		1776.593	600		
				Mn IV		1777.023	300		
1777.65	+35	-		Fe III		1777.737	70		
1778.70	+47	-		Si III		1778.715P	?		
1780.65	-14	1781.00	-22	O III		1781.03	600		
1782.20	+48	-		Mn IV		1782.212	750		
1783.05	+16	-		Mg III		1783.253	550		
1783.85	+37	-		Ca III		1783.929	500		
1784.75	+33	1785.00	+ 8	O III		1784.65	600		
1785.75	+ 4	-		Mn IV		1786.025	750		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1786.95	+35	1787.30	+27	Mn IV		1787.040	750		
1789.60	+40	-		O III		1789.66	700		
1790.35	+35	-		Mn IV		1790.442	750		
1794.20	+46	-		Ca III		1794.223	500	blended	
1795.70	+58	1795.90	+25	Mn IV		1795.650	800		
				Mn IV		1795.786	800		
1796.95	-10	-		Cl III	7	1797.98	200		18.10
1798.45				?					
1798.60		1798.80		?					
1800.40	+12	1800.80	+14	Mg III		1800.662	350		
1801.60	+21			Fe III		1801.766	200		
1801.90	+17			Mn IV		1802.090	150		
1807.75	+27	1808.10	+20	Ca III		1807.885	650	well defined	
1809.60	+ 7	1809.80	-25	V IV		1809.854	60		
1810.00	+ 6	1810.30	- 9	Cl III	7	1810.26	100		18.10
1812.50	-29	1812.70	-61	Fe III		1812.974	150		
1813.20	-15			Ca III		1813.585	550		
1815.00	+41			Cr IV		1815.05P	100		
1817.60	+36	1817.60	-29	V IV		1817.676	100		
				Cl III	7	1817.73	400		18.12
1818.55	+49	1818.80	+25	Al IV		1818.55	50d		
1820.50	+50	1820.70	+18	Fe III		1820.496	70		
1824.60	+52	1824.55	-23	Cl III	7	1824.59	300		18.21
1826.15	+47	1826.10	-26	Cr IV	12	1826.16	150		12.98
1826.65	+23	1826.80	-18	Cr IV	16	1826.81	150		13.67
1828.15	+ 8	1828.10	-65	Cl III	7	1828.40	500		18.16
1829.40	+33	1829.45	-24	Ni IV		1829.497	200		
1830.20	+72	1830.20	+ 7	Ca III		1830.059	600		
1837.40	+18	1837.35	-55	Fe III		1837.588	250		
1841.40	+27	1841.65	+ 3	Fe III		1841.536	300		
1842.55	+49	-		Si III		1842.547	180		
1843.15	+ 7	1843.30	-34	Fe III		1843.409	250		
				Fe III	117	1843.502	150		10.95
1843.60	-16	1843.80	-48	Fe III		1843.999	200		
1843.95	+13	1844.10	-27	Mg IV		1844.169	300		
1844.30	+ 9	1844.60	- 7	Fe III	117	1844.547	400		10.95
1845.30	+48	1845.60	+32	Fe III	117	1845.304	300	blended	10.95
1848.25	+47			O III		1848.26	500		
1849.20	+15			Fe III	97	1849.407	450		10.26
1849.80	+23	1850.00	-10	Fe III	53	1849.960	300		7.83
1850.80	0	1851.10	-14	Ca III		1851.090	150		
				Fe III		1851.261	400		
1854.40	-20	1854.85	-12	Fe III	63	1854.826	800		8.62
1855.15	+77			Fe III	63	1854.975	300		8.62
1855.50	+47			Fe III		1855.510	200		
1856.20	-30			Fe III	63	1856.690	450		8.62
1857.90	+68			N V	60	1857.78	50		
1858.50	+42	1858.60	- 7	Fe III	63	1858.542	300		8.61
1859.95	+71	1860.40	+78	Fe III		1859.813	300		
				Fe III	63	1859.955	200		8.62

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1860.55	+68	1860.80	+43	Ca III		1860.432	500		
1861.35	+15	1861.60	- 9	V IV		1861.558	300		
1861.65	+47	1861.90	+22	Fe III	63	1861.665	200		8.62
1863.15	+22	1863.50	+13	Fe III	62	1863.317	250		0.00
1863.85	+53	1864.00	+12	Ca III		1863.826	400		
1864.70	-32	1865.20	-16	Fe III		1865.202	450		
1865.15	+ 2	1865.50	- 7	Fe III	154	1865.445	150		11.98
1865.60	+48	1865.70	- 1	Fe III		1865.606	150		
1866.10	+14	1866.00	-65	Fe III	52	1866.305	600		7.84
1866.75	+23	1866.90	-16	Fe III		1866.900	150		
1869.50	- 6	1869.70	-37	Fe III	52	1869.828	650		7.84
1870.65	+109			Ca III		1870.263	700		
1871.10	+39	1871.00	-40	Fe III	52	1871.152	600		7.84
1871.40	+60	-		Fe III		1871.319	150		
1872.00	+13	-		Fe III		1872.214	400		
1872.50	+ 2	-		O III		1872.78	800		
				O III		1872.87	800		
1873.35	+18	1873.30	-53	Fe III		1873.534	150		
1873.70	+21	1873.65	-50	Cr IV	11	1873.86	125		12.84
1874.70	+ 9	1874.90	-22	O III		1874.94	800		
1877.65	- 7			Fe III	63	1877.989	800		8.60
1880.00	+21	1880.30	+16	Cl III		1880.10	300		
1881.20	+51	1881.40	+19	Fe III		1881.178	300		
1881.55	+43	1881.60	-12	Fe III		1881.578	200		
1882.00	+40	1882.30	+24	Fe III	62	1882.047	650		8.62
1882.40	+56			Fe III		1882.357	300		
1882.65	- 5			Fe III	62	1882.979	250		8.62
1884.20	+39	1884.50	+23	Fe III		1884.253	150w		
				Fe III	62	1884.596	550		8.62
1884.90	+11	1884.80	-68	Fe III	96	1885.125	600		10.26
1885.90	+40	1885.90	-23	Fe III	96	1885.947	300		10.27
1887.00	+23	1887.00	-40	Mn IV		1887.151	350		
				Fe III	53	1887.197	550		7.84
1888.35	- 1	1888.50	-40	P IV	5	1888.65	400		12.99
1889.50	+55			Fe III	53	1889.451	300		7.84
1889.65	+34			Fe III		1889.735	250		
1891.30	+65	1891.50	+34	Fe III	96	1891.186	200		10.29
				Fe III		1891.339	70		
				Fe III		1891.516	300w		
1891.70	+24	1891.95	0	Mn III		1891.846	200		
				Fe III		1891.909	200		
1892.70	+17	1892.80	-30	Fe III	96	1892.890	300		10.27
1893.70	+16	-		Mg IV		1893.898	200		
1893.90	+34	1894.00	+13	Fe III	83	1893.981	700		9.86
1894.15	+51			Ca III		1894.124	500		
				Fe III		1894.252	300		
				C III		1894.29	200		
1894.85	+26			Fe III	96	1894.983	250		10.28
1895.55	+62	1895.70	+23	Fe III	34	1895.456	1000		3.71
1896.30	+42			Fe III		1896.333	250		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1896.55	+18			Fe III		1896.734	250		
				Fe III	83	1896.803	600		9.86
1897.80	+39	1897.80	-24	Cl III	8	1897.85	300		18.75
1898.60	+ 4	1898.65	-51	Fe III		1898.870	400		
1899.15	+20			Fe III	96	1899.318	300		10.30
1900.00	+57			Fe III		1899.931	300		
1900.40	+18			Fe III		1900.575	70		
1901.00	+31			Fe III	95	1901.096	600		10.26
1901.45	+21	1901.70	- 1	Cl III	8	1901.61	500		18.75
1901.75	- 5			Fe III		1902.076	300		
1902.05	-10	1902.40	-15	Fe III		1902.402	400		
1902.75	+22			Fe III		1902.902	300		
1903.10	+37			Fe III		1903.159	70		
				Fe III		1903.257	200		
1903.25	-26	1903.60	-32	Fe III		1903.706	70		
1903.70	+ 1			Fe III		1903.983	70		
1904.10	- 2	1904.20	-47	Fe III		1904.402?	250		
1904.50	+ 1			Fe III	139	1904.784	300		2.53
1906.15	+35	1906.20	-18	N III		1906.22	100A		
1907.40	+65			N III		1907.28	400A		
				Ca III		1907.383	450		
				Fe III	83	1907.577	650		9.86
1907.85	+24			N III	27	1907.99P	300A		41.30
1908.75	+131			N III	27	1908.21	400A		41.30
1910.20	+38			Mn IV		1910.251	750		
				Fe III	57	1910.401	400		8.21
1911.35	+48			Fe III	135	1911.338	450		11.42
				Ca III		1911.692	450		
				Fe III		1911.703	150		
1914.10	+53			Fe III	34	1914.056	1000		3.71
				Cl III	8	1914.09	300		18.75
1917.35	+30	1917.70	+24	Fe III	101	1917.453	600		10.30
1918.00	+52	1918.00	- 9	Fe III		1917.960	400		
1918.40	+33	1918.50	-12	Fe III	108	1918.480	450		10.45
1920.20	+12			Cl III		1920.32	400		
1920.50	+ 7			O III		1920.75	500		
				N III	29	1920.86	400A		41.51
1921.05	+33	1921.30	+11	Fe III		1921.132	150		
1921.50	+48	1921.70	+18	N III	29	1921.49	200-A		41.51
1921.75	+82			O III		1921.52	500		
1922.50	-26			Fe III	51	1922.789	1000		7.83
				Fe III	95	1923.003	450		10.28
1923.10	+37	1923.40	+22	C III	12.02	1923.16	200		33.48
				C III	12.02	1923.34	200		33.48
1923.35	+24			O III		1923.49	700		
1923.90	+59	1924.10	+29	O III		1923.82	500		
				Fe III		1923.877	450		
				Fe III		1924.119	250		
1924.15	-14			Fe III	79	1924.532	400		9.50
1925.35	+58			Fe III		1925.271	250		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1926.00	+44	1926.10	- 1	Fe III		1926.013	500		
				Na III		1926.27	900		
1926.50	+77			Fe III	34	1926.304	1000		3.71
1927.15	+79			O III		1926.94	500		
1927.50	+18			Fe III		1927.679	150		
1928.00	+ 5	1928.50	+22	Fe III	95	1928.265	300w		10.28
1929.00	+54			Mn IV		1928.95	200		
				Fe III		1929.413	250w		
				Fe III	51	1929.632	70		7.84
1930.05	+25	1930.20	-13	Fe III		1930.184	150w		
1930.55	+27			Mg III		1930.672	250		
1931.40	+29			Fe III	61	1931.507	950		8.60
1935.50	+12			Ca III		1935.72	600		
1939.90	+28			Fe III	61	1940.018	550		8.60
1940.55	+31	1940.70	- 7	Fe III	37	1940.649	500		0.05
1941.90	+ 1	1942.10	-29	Na III		1942.19	120		
1943.50	+49			Fe III	51	1943.481	950		7.84
1945.10	+ 9			Fe III	61	1945.342	800		8.62
1946.70	+35	1947.10	+36	Fe III		1946.769	200		
1947.25	+35			Mn III		1947.320	150		
1948.35	+57			Fe III		1948.280	200		
				Mn III		1948.282	200		
1948.95	+ 4	1948.80	-80	N III		1949.22	300		
1949.45	+13	1949.20	-87	Fe III	95	1949.666	200		10.33
1949.95	+75	-		N III		1949.76P	200		
1949.95	-13	-		Fe III	116	1950.334	650		
1951.05	+52	1951.30	+30	Fe III	68	1951.007	800		8.73
				Fe III	68	1951.318	200		8.73
1951.90	+ 9	1952.10	-20	Ca III		1952.133	450		
1952.85	+49	1952.90	- 3	Ca III		1952.823	200		
1953.40	+31			Fe III		1953.488	650		
				Ca III		1953.546	500		
1954.35	+64			Fe III	61	1954.223	650w		8.62
1955.00	+49	1954.95	-19	Fe III	116	1954.975	550		10.95
1955.30	-11			Mn IV		1955.663	300		
1956.90	+ 9			Fe III		1957.137	200		
1957.25	+26			Fe III		1957.375	150		
1962.60	+27			Fe III	61	1962.717	300		8.61
1966.30	+79			Fe III		1966.074	200		
				Fe III	61	1966.201	150		8.21
1966.80	+54	1966.70	-21	Fe III	116	1966.740	550		10.95
1967.30	+37	1967.20	-38	Fe III		1967.352	250		
1968.50	+26			Fe III		1968.625	150		
1976.00	+26	1976.25	+ 4	Fe III	54	1976.126	550		8.21
1976.85	+20	1977.00	-17	Ca III		1977.013	500		
1979.30	+21	1979.50	- 9	Cl III		1979.46	300		
				C III	41	1979.62	50A		
1982.00	+33			Fe III	54	1982.076	400		8.21
1982.70	+29	1982.90	- 1	Fe III	56	1982.805	550		8.21
1983.20	-27			Fe III	81	1983.676	150		

Table I (continued)

SWP 13729 16 Apr., 1981		SWP 14805 24 Aug., 1981		Spec-trum	Mult.	l_{lab}	Int.	Remarks	χ (eV)
$l_{meas.}$	RV	$l_{meas.}$	RV						
1983.80	+11			Fe III	86	1984.027	450		10.17
1992.50	- 9			Fe III	106	1992.858	400		10.42
1993.30	-10			Fe III	50	1993.262	450		7.83
1993.75	- 4			Fe III	50	1994.073	900		7.84
1999.00	+30			Fe III		1999.100	70		
				V IV		1999.320	200		

P=predicted, d=diffused, b=blend, w=wide, ?=identification remains doubtful.

TABLE II

Average velocities of lines of 9 Sgr

Ion	i.p. (eV)	SWP 13729 (16 Apr., 1981)				SWP 14805 (24 Aug., 1981)			
		RV σ (km s^{-1})	No. of lines			RV σ (km s^{-1})	No. of lines		
			Tt	Cl	In		Tt	Cl	In
Ca III	11.87	+ 34 ± 25	34	0	29	- 8 ± 29	27	0	25
Fe III	16.18	+ 24 ± 26	160	68	159	- 14 ± 21	101	40	86
Si III	16.35	+ 16 ± 20	28	24	25	- 27 ± 23	24	23	20
Cl III	23.81	+ 18 ± 10	9	6	7	- 8 ± 14	7	5	6
N III	29.60	+ 36 ± 21	14	7	13	- 4 ± 14	9	4	8
Cr IV	30.96	+ 35 ± 12	16	7	13	- 27 ± 15	15	6	12
Mn IV	33.67	+ 34 ± 15	62	0	53	- 12 ± 30	46	0	43
N IV	47.45	+ 36 ± 21	18	17	16	- 29 ± 20	16	15	13
Fe V	51.20	+ 28 ± 9	8	0	6	- 21 ± 26	7	0	6
O IV	54.80	+ 30 ± 22	34	0	29	- 10 ± 18	33	0	29
Cr V	54.93	+ 21 ± 19	6	0	5	- 6 ± 32	4	0	4
O V	55.20	+ 40 ± 21	9	0	8	- 27 ± 22	8	0	8
N V	77.41	+ 25 ± 19	9	1	7	- 12 ± 12	9	1	8
Mg IV	77.47	+ 23 ± 6	5	5	3	- 25 ± 22	4	4	4
	80.14	+ 17 ± 21	35	0	32	- 26 ± 22	31	0	26

i.p. = low ionization potential, RV = radial velocity, σ = standard error, Cl = classified, In = lines included in the average velocity.

3. Description of the Spectrum and Discussion

3.1. General Description of the Spectrum

The far UV spectrum of 9 Sgr presents a great variety of ionized species ranging from H I to the highly ionized species such as N V, N IV, C IV, and Si IV.

Table III gives the characteristics of certain lines of high ionization for both spectra

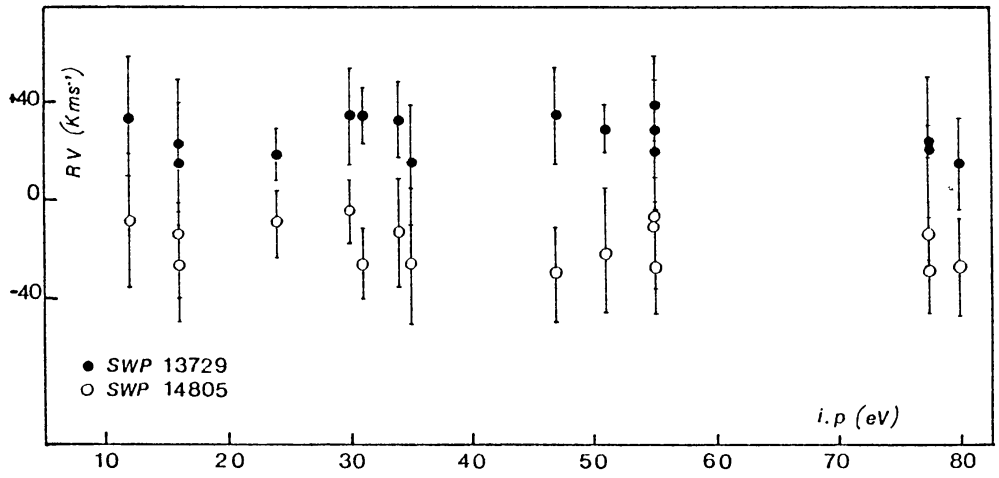

Fig. 1. The average radial velocities in km s^{-1} versus the ionization potential in eV. Dots represent the RVs for SWP 13729 and open circles for SWP 14805.

TABLE III

Main characteristics of high ionization lines

λ (Å)	Ion	i.p. (eV)	Blue edge velocity (km s^{-1})		Emission peak (km s^{-1})		Absorption core (km s^{-1})	
			SWP 13729	SWP 14805	SWP 13729	SWP 14805	SWP 13729	SWP 14805
1393.750	Si IV	33.49	− 483 ± 43	− 397 ± 43	–	–	+ 11 ± 43	− 21 ± 43
1402.770	Si IV	33.49	− 250 ± 43	− 290 ± 43	–	–	− 4 ± 43	− 20 ± 43
1718.55	N IV	47.45	− 228 ± 35	− 357 ± 35	+ 305 ± 35	+ 236 ± 35	− 9 ± 35	− 43 ± 35
1548.185	C IV	47.89	− 358 ± 39	− 3629 ± 39	–	–	–	–
1550.770	C IV	47.89	–	–	+ 256 ± 39	+ 663 ± 39	–	–
1238.82	N V	77.47	− 3467 ± 48	− 3613 ± 48	–	–	–	–
1242.80	N V	77.47	–	–	+ 604 ± 48	+ 338 ± 48	–	–

Blue edge velocity of some lines with low ionization potential

λ (Å)	Ion	i.p. (eV)	SWP 13729	SWP 14805
1302.168	O I	0	− 115 ± 20	− 117 ± 20
1260.540	Si II	8.15	− 116 ± 20	− 114 ± 20
1250.500	S II	10.36	− 116 ± 20	− 116 ± 20
1334.53	C II	11.26	− 113 ± 20	− 114 ± 20

of 9 Sgr. The first column gives the laboratory wavelength of these lines in Å and the second the ion producing the line. The third column gives the low-ionization potential in eV, while the next six columns give the blue edge velocity, the radial velocity of the emission peak and the velocity of the absorption core in km s^{-1} for both spectra in the above order. This table includes the observed emission lines N V [1] at λ1240 Å, C IV [1] at λ1550 Å, and N IV [7] at λ1718.55 Å, the resonance lines with broad and asymmetrical

absorption (as the N V [1], C IV [1], and N IV [7] lines) and the resonance lines Si IV [1] with observed broad and symmetrical absorption with their blue edge velocities.

In the second part of Table III the blue edge velocities of four lines of low-ionization potential are given to help us plot Figure 2, which gives the blue edge velocities of these

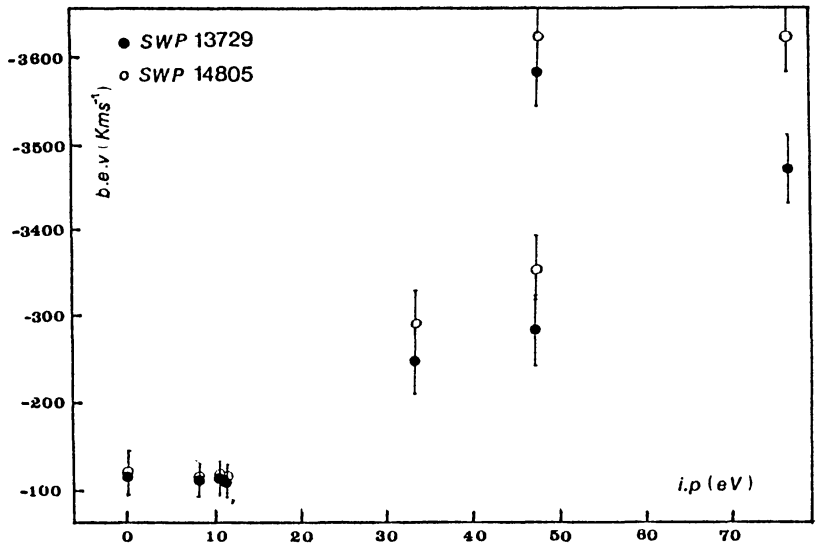

Fig. 2. The blue edge velocities (in km s^{-1}) of some lines of high ionization for both spectra from Table III together with some lines of low-ionization potential from both Tables I and II. Dots represent the RVs of SWP 13729 and open circles for SWP 14805.

four lines as well as of the lines described in the upper part of Table III with error bars taken from both Tables I and II. In this figure dots represent the radial velocities of SWP 13729 and open circles for SWP 14805.

Figure 3 gives the resonance lines of Si IV λ1393 and λ1402 Å for both spectra. On

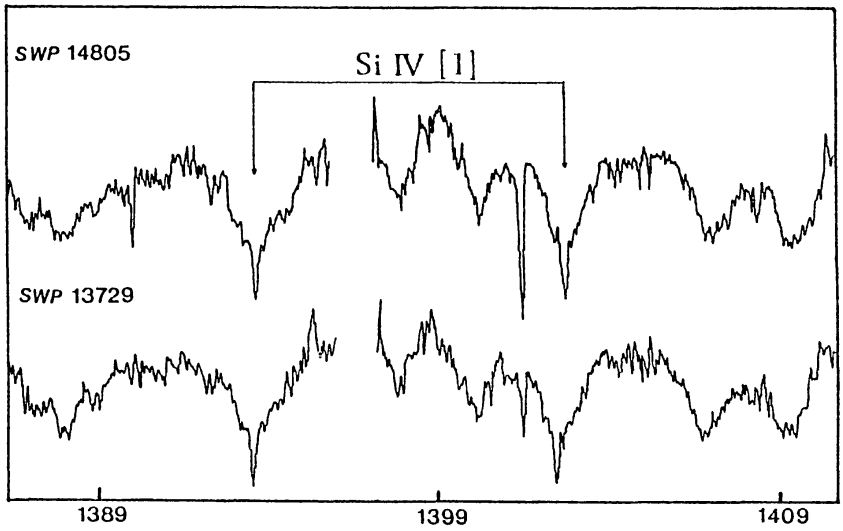

Fig. 3. The resonance lines of Si IV λ1393 and λ1402 Å for both spectra. Bars indicate the laboratory wavelengths of the lines.

this figure bars indicate the laboratory positions of these lines. Other lines are included in the tracings for comparison of their shapes in the two spectra.

Figure 4 gives the structure of C IV [1] resonance lines (included in Table III). One can identify the interstellar C IV [1] lines at 1548 and 1551 Å and on the far end the interstellar C I lines at λ1561 Å.

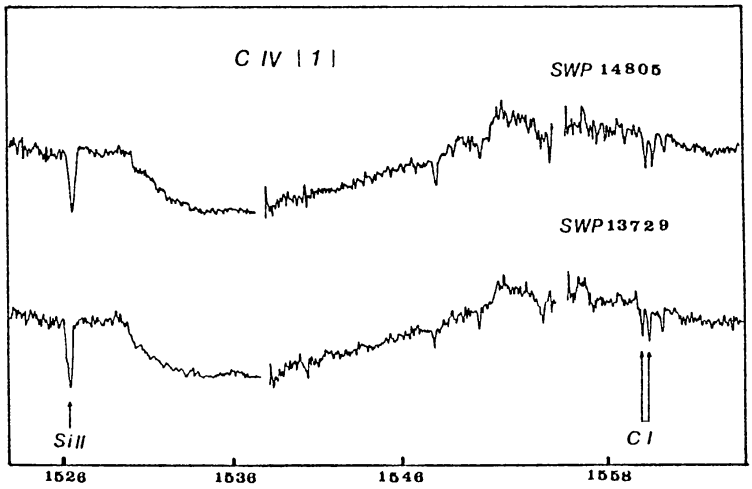

Fig. 4. The structure of the C IV [1] resonance lines. The interstellar C IV and C I lines at $\lambda\lambda$1548, 1551 Å and 1561 Å, respectively, are also shown.

Figure 5 gives the shape of the N V [1] resonance lines at λ1239 and λ1234 Å, which are blended with the N IV lines at λ1225 and λ1247 Å and of course with the Lα line at λ1215 Å. Some interstellar lines are identified in these segments of the two spectra (e.g., the N I [1] and the S II [1] lines).

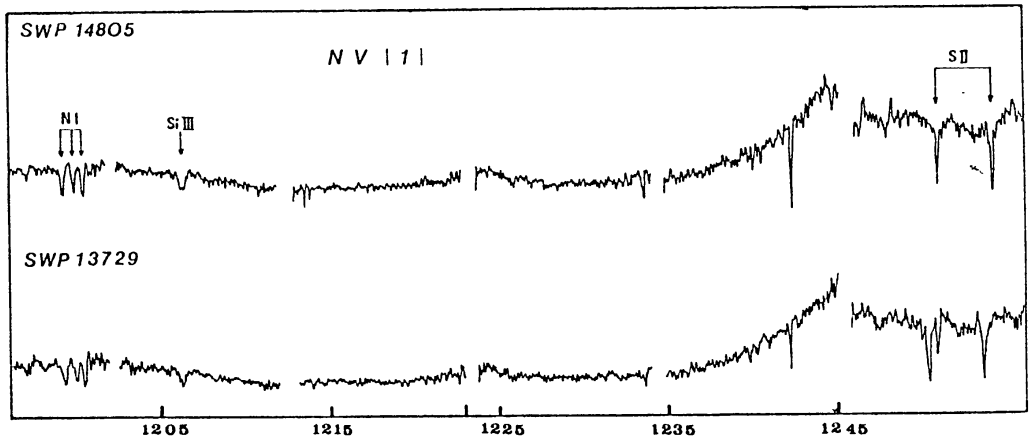

Fig. 5. The N V resonance lines at λ1239 and λ1243 Å, which are blended with the N IV lines at λ1225 and λ1247 Å and the Lα line at λ1215 Å. Some interstellar lines are also identified.

Finally Figure 6 gives the shape of the N IV [7] line at λ1720 Å which presents a P Cygni profile.

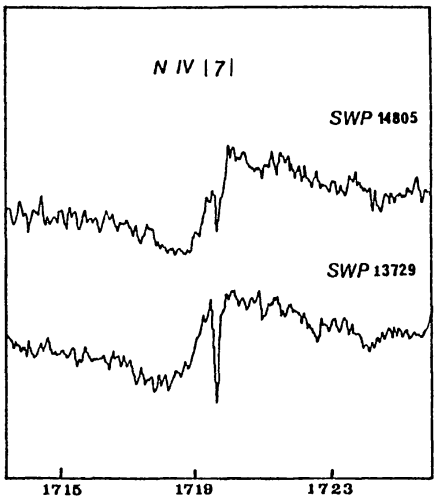

Fig. 6. The N IV [7] line at λ1720 Å, which presents a P Cygni profile.

3.2. The observed spectrum

The spectrum is dominated by shell absorption lines. Most of them present narrow absorption cores blended with the corresponding interstellar lines.

Below we present a summary of the relevant atomic species and some comments on their presence or absence are given.

Hydrogen

H II: This ion is probably present as a part of a blend with Lα.

Helium

He II: Lines of this element are present.

Carbon

C I: This ion is absent.

C II: This ion is probably present. The two resonance lines at $\lambda\lambda$1334.60 and 1335.75 Å of multiplicity 1 are the main contributors to the C II spectrum.

C III: This ion is probably present predominantly in a moving shell, as it is shown by the shortward-displaced absorption lines from multiplet 5 around 1175 Å. The intercombination line at 1908.734 Å is not present in absorption or emission.

C IV: This ion is present in the expanding shell and in the photosphere. All possible lines in our spectral range that are not masked by strong features have been detected.

Nitrogen

N III: This ion is present in the photospheric spectrum.
Coincidences occur with 16 lines listed in Table I.

N IV: This ion is present in the photosphere, all of the strongest lines being found. Coincidences occur with 23 lines listed in Table I.

The intercombination line at λ1486.496 Å is not present in absorption or emission.

N V: The N V resonance lines are present as strong shortward-displaced absorption lines with longward-displaced emission components.

Oxygen

O III: This ion is present. Twenty-three of the 27 strong lines between $\lambda\lambda$1760 and 2000 Å are present.

O IV: This ion is probably present. Six lines have been attributed, at least in part, to O IV, including $\lambda\lambda$1343.512 and 1338.612 Å, which show a small displacement and additional absorption in the short-wavelength wings. However, some moderately strong lines are not detected.

O V: This ion is possible present.

The strong line of O V at λ1371.35 Å of multiplet 7, which has a lower E.P. of 19.69 V, may be present as a part of a blend with Fe V and Si III. It appears that this line has an extended short-wavelength wing due to the expanding envelope.

Four lines of O V in the neighbourhood of λ1418 Å are also detected.

The intercombination line from the ground state at λ1218.406 Å is not present in absorption or emission.

Neon

Ne III: This ion is possibly present. Two lines at $\lambda\lambda$1255.03 and 1255.68 Å of multiplet 13 of the three listed near λ1256 Å are found.

Magnesium

Mg III: This ion is probably present. The eight stronger lines of intensity ≥ 250 listed by Kelly and Palumbo (1973) have been identified.

Mg IV: This ion is probably present. Fifty-three lines of intensity ≥ 100 are listed by Kelly and Palumbo (1973) in the region $\lambda\lambda$923 to 2000 Å. Coincidences are found with 33 of these lines in the region $\lambda\lambda$1174–1999 Å. Another four coincidences were found with weaker lines listed in Table I.

Aluminium

Al IV: This ion is not present. Kelly and Palumbo (1973) list 49 lines between 1118 and 1881 Å, but only five (at λ1257.58, 1441.81, 1447.47, 1557.24, and 1818.55 Å) coincide.

Silicon

Si II: This ion is absent. Most of the major lines are not found. Evidence is found for lines of only 4 multiplets. Coincidences are listed in Table I. The level of ionization of Si II is low for appearance in the spectrum of 9 Sgr.

Si III: This ion is possibly present. A few strong lines seem to appear but many are missing. All possible coincidences with Si III lines (30 lines) are entered in Table I.

The intercombination line from the ground state at λ1892.23 Å is not present in absorption or emission.

Si IV: This ion is present. The two resonance lines of Si IV at $\lambda\lambda$1393.85 and 1402.80 Å are present.

Phosphorus

P III: This ion is probably absent. Coincidence is found with only one out of 5 lines of intensity 1000 in the 1344–1700 Å spectral region, namely the λ1502.27 Å. No lines are listed longward of 1700 Å.

P IV: This ion is probably absent. Coincidences with 2 lines were found and given in Table I.

P V: This ion is probably absent. Coincidence is found with only 1 line at λ1447.92 Å.

Sulphur

S III: This ion is absent.

S IV: This ion is possibly present. The resonance lines of S IV at $\lambda\lambda$1072.99 and 1073.52 Å are not recorded in our spectrum.

Coincidences with 5 other lines are found and given in Table I.

S V: No lines are known in the observed wavelength range.

Chlorine

Cl III: This ion is possible present. Coincidences are found with 11 lines of intensity ≥ 100 and are entered in Table I.

Cl IV: This ion is possibly present. Coincidences are found with 4 lines of intensity ≥ 100 and given in Table I.

Argon

Argon is absent.

Calcium

Ca II: This ion is possibly present. This spectrum contains many strong lines in the region observed; coincidences are found with 39 lines (22 of intensity ≥ 500) and are entered in Table I.

Titanium

Ti IV: This ion is not present. Kelly and Palumbo (1973) list 5 lines in the range 1175–1470 Å and only two coincide with lines observed in 9 Sgr.

Ti V: No Ti V lines are listed in the wavelength sources for the observed spectral region.

Vanadium

V IV: This ion is not present. Coincidences with only 4 lines are entered in Table I.
V V: This ion is not present. Coincidence is found with only one line at λ1716.722 Å.

Chromium

Cr III: This ion is not present.
Cr IV: This ion is possibly present. Laboratory spectra reveal strong lines in the observed region. Coincidences with 18 weak lines of intensity ≥ 40 are entered in Table I.
Cr V: This ion is possibly present. Coincidence with 5 lines of intensity ≥ 100 are entered in Table I.

Manganese

Mn III: This ion is absent. Coincidences are found with only 3 lines entered in Table I.
Mn IV: This ion is present. Many strong lines are known in the studied region and coincidences are recorded with 66 (34 of intensity ≥ 500) lines and are entered in Table I.
Mn V: This ion is present. Eight lines are known in the region 1431–2000 Å and all are found and are entered in Table I.

Iron

Fe III: This ion is possibly present. The weak lines of multiplets 34, 62, 63, 64, and 84 are found.
Fe IV: This ion is probably not present. Kelly and Palumbo (1973) list no lines in the range 923–2000 Å.
Fe V: This ion is present. Kelly and Palumbo list 45 strong lines between $\lambda\lambda$1302 and 1554 Å and 35 of them are present or masked by strong absorption lines of other ions.

Nickel

Ni IV: This ion is present. Twenty-three lines of intensity > 500 coincide with the 32 stronger lines listed between $\lambda\lambda$1306 and 1829 Å. Another 23 coincidences with Ni IV are listed in Table I.
Ni V: This ion is probably absent. Ten lines are known between $\lambda\lambda$1123 and 1520 Å. Coincidences occur with only 4 lines at $\lambda\lambda$1264.46, 1300.97, 1306.60, and 1318.47 Å.

There is no evidence of elements heavier than nickel.

We could summarize our conclusions about the atomic and ionic spectra visible in the ultraviolet spectrum of 9 Sgr as:

(1) He I, He II, C IV, N III, N IV, N V, O III, O IV, Mg III, Mg IV, Si IV, Mn IV, Mn V, Fe V, and Ni IV are present or probably present in the photospheric spectrum.

(2) C III, O V, Ne III, Si III, S IV, Cl III, Cl IV, Ca III, Cr IV, Cr V, and Fe III are possibly present in the photosphere.

(3) C I, C II, Al IV, Si II, P III, P IV, P V, S III, S V, Ar, Ti IV, Ti V, V IV, V V, Cr III, Mn III, Fe IV, and Ni V are probably absent.

4. Conclusions

The main features in the two spectra remain the same. They follow almost identical curves in the radial velocity-ionization potential diagram. This suggests that no variability exists in both the photospheric and the shell lines.

Additionally the heavy blending of the shell lines does not permit the clear measurement of equivalent widths, which could certainly indicate the existence or not of variations. The asymmetry of the spectral lines included in Table III did not change from the one spectrum to the other. Franco *et al.* (1983) had included 9 Sgr in their search for line variability among O stars in the ultraviolet. The same resonance lines of the same spectra had been examined by them but no variability was found.

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