

THE IUE SPECTRUM OF AX MONOCEROTIS

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RESUMEN. Imágenes de AX Monocerotis obtenidas en alta dispersión con el satélite ultravioleta IUE, en una sola fase del ciclo orbital, han sido analizadas desde el punto de vista del espectro continuo así como del espectro de líneas. El continuo corresponde al de la componente temprana del sistema. Se da una lista de identificaciones del espectro de líneas y se propone un modelo para la envoltura extendida.

ABSTRACT. High dispersion IUE images of AX Monocerotis, secured at one single phase of the orbital cycle, were analyzed for the continuous as well as for the line spectrum. The continuum corresponds to that of the early type component of the system. A list of line identification is given and a model is proposed for the extended envelope.

I. INTRODUCTION

AX Monocerotis [HD 45910 = BD + 5°1267 = SAO 113974; $\alpha = 6^h 27^m 52^s$, $\delta = +5^\circ 54' 1''$ (1950.0); $V = 6.59-6.88$ mag.] is a binary system with a B3nn and a K0 III components, the orbital period being 232.5 days, and the rotational velocity of the early-type star, 345 km/s (Cowley 1964). According to Cowley's orbital elements, periastron passage occurs a few hundredths of the period after the quadrature at which the late-type component, in its orbital motion, reaches the maximum velocity of recession.

The photographic spectrum can be described as displaying (cf. Cowley 1964)

- a) lines of the two stellar components;
- b) P Cygni profiles in H (and occasionally in He I), the absorption being variable & from time to time becoming double or multiple, the velocities being of the order of -150 and -250 km/s, respectively.
- c) *on rare occasions*, weak absorptions of Ni II 4067 and Fe II 4233 with the same displacements as the H lines;
- d) weak, hazy emission of Fe II;
- e) occasional, faint [Fe II] (essentially 4244) emission, varying from hazy to reasonably sharp, the average velocity being +1.4 km/s;
- f) structure in the resonance lines of Ca II and Na I: an interstellar feature, one or more components with the same displacements as the H P Cygni absorptions, and a shell component [cf. g)];
- g) a shell-like spectrum displaying Mg I, Mg II, Si I, Si II, Sc II, Ti II, Cr II, Fe I, Fe II and Ni II, which is present from some 7 weeks before to a few weeks after the conjunction at which the B star is behind; the velocities are of recession, before conjunction, and of approach, after conjunction.

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The shell lines have been interpreted as being produced by an eclipse of the B star by an extended atmosphere around the K component, and by the presence of a gaseous stream from the latter object towards the early-type companion.

When the shell spectrum is present, the hazy Fe II emission appears as double because of the absorption effect of the corresponding Fe II shell line, thus suggesting that the Fe II emission arises in a region around the B star or between the two components of the system.

Struve (1943), the Burbidges (1954) and Cowley (1964) have called attention to the fact that sometimes the violet H ϵ absorption is suppressed, with no reasonable explanation so far offered.

Cowley's derived orbital elements are

$$K_K = 51.5 \text{ km/s}$$

$$\gamma = + 6.5 \text{ km/s}$$

$$e = 0.02$$

$$a \sin i = 1.64 \times 10^8 \text{ km}$$

$$f(M) = 3 M_{\odot}$$

From the velocities derived from the lines of the early-type component it would appear that the masses should be $8.6 M_{\odot}$ for the B component and $3.4 M_{\odot}$ for the K companion, if an inclination of 65° is adopted. If these were the values of the masses, the separation of the components would be of the order of $300 R_{\odot}$.

AX Mon has been found to have intrinsic polarization (cf. Serkowski 1970, Pfeiffer and Koch 1977). The object was not detected as a radio source at 10.6 GHz (Woodsworth and Hughes 1977) and is not known to be an X-ray source either.

AX Mon was considered by Swings (1970) as a symbiotic-related star. In fact, we are dealing here with a *combination spectrum* -an early-type object, although not a subdwarf, and a late-type giant, although earlier than M- and an orbital period similar to those one finds among symbiotic binaries. The study of AX Mon, therefore, could throw light on the evolutionary history of symbiotic stars. As a consequence, one of us (J.S.) included this binary in his observing program of symbiotic stars with the IUE satellite, in January, 1979. The high dispersion images that were obtained are listed in Table 1; they were secured with large aperture from the NASA IUE ground observatory at the Goddard Space Flight Center, in Greenbelt, Maryland, U.S.A. Unfortunately, there are no observations in other wavelength ranges simultaneous or contemporaneous with our IUE observations.

TABLE 1

IUE IMAGES OF AX MONOCEROTIS

Image*	U.T. of Start of Exposure				Exposure Time (Minutes)	Phase** (P)
	Year	Day	Hour	Minutes		
SWP 3374	1979	1	21	12	65	0.095
LWR 3353	1979	1	22	24	20	0.095

* SWP: short wavelength prime camera; range: 1165-2126 Å .

LWR: long wavelength redundant camera; range: 1845-3230 Å

** The phases were computed from the expression

$$2,433,390.8 + 232.5 \text{ days}$$

given by Cowley (1964) for the time of periastron passage.

If we take as origin the conjunction at which the K component is in front, the phase of the two images is 0.38 P.

II. THE CONTINUUM SPECTRUM

In a previous paper (Sahade, Brandi and Fontenla 1984) on the IUE observations of symbiotic objects, we have reported on the fitting with Kurucz's (1979) LTE model atmosphere

calculations of the ultraviolet continuum of AX Mon, calibrated, in absolute flux units, with the use of the method suggested by Cassatella *et al.* (1981). The fitting was good for $T_e=20000^\circ\text{K}$ and $\log g \sim 2.5$. The temperature is what we would have for spectral type around B2, and the gravity value would suggest that we are dealing with a giant object. Therefore, the fitting with Kurucz's models would describe the ultraviolet continuum of AX Mon as that of a B2 (or B3) III object, in coincidence with the listing of the star by Batten, Fletcher and Mann (1978), but at variance with the suggestion from the photographic spectrum that we are dealing with a main sequence star (Struve 1943).

III. THE LINE SPECTRUM

The ultraviolet line spectrum of AX Mon is essentially one of absorption features, except in the case of the resonance lines of Mg II at 2800 Å which display a P Cygni profile. Table 2 lists the identifications made.

TABLE 2
ULTRAVIOLET LINES IN THE SPECTRUM OF AX MON

λ obs. (Å)	FWHM (Å)	IDENTIFICATIONS				λ obs. (Å)	FWHM (Å)	IDENTIFICATIONS			
		ELEMENT	MULT.	λ lab. (Å)	INT:			ELEMENT	MULT.	λ lab. (Å)	INT:
1188.9		SiII	5	1190.42	100	1275.0		FeII	9	1275.80	400
1189.4		SiIII	1	1190.17	200	1275.4					
1189.8						1277.2		Cl	7	1277.282	700
1190.45	0.1	SiIII	1	1190.17	200					1277.245	300
1190.55	0.1	SiII	5	1190.42	100	1277.35		Cl	7	1277.55	1000
1192.5		SiII	5	1193.289	200	1277.6		Cl	7	1277.72	250
		SiIII	1	1194.02	400						
1193.5		SiII	5	1194.500	250	1280.0		Cl	5	1279.89	250
		SiIII	1	1194.02	400	1280.25	0.1	Cl	5	1280.33	700
				94.40	300	1281.9		TiIII	2	1282.48	125
1196.0	1.5	SiII	5	1197.394	100	1283.65		NiIII		1284.327	25
1196.6						1285.8	0.9	TiIII	2	1286.365	700
1197.0						1288.65	0.6	TiIII	2	1289.30	500
1200.0	4.0	SiIII	1	1200.97	400	1290.9	0.9	TiIII	2	1291.62	450
				01.71	200			FeII	9	1291.714	600
				02.10	50			FeII	9	1291.618	300
		Ni	1	1199.549	1000	1292.7	0.5	TiIII	2	1293.23	400
				1200.224	950			FeII	9	1293.661	200
				.711	700	1293.9	1.4	TiIII	1	1294.70	600
1226.4		SiII	8.02	1227.604	100	1295.8	1.3	TiIII	1	1295.88	400
1228.0		SiII	8.01	1228.746	150			FeII	86	1296.088	400
1228.8		SiII	8.01	1229.388	200	1298.0		TiIII	1	1298.66	1000
1229.9		NiII		1231.041	100			TiIII	1	1298.97	800
1230.3						1298.8	1	TiIII	1	1298.66	1000
1232.5		?				1301.2	2.2	OI	2	1302.17	1000
1235.5		?				1302.3		OI	2	1302.17	1000
1238.8	2.5	NV	1	1238.821	1000	1303.08		OI	2	1304.86	600
1242.8	1.3	NV	1	1242.804	800			SiII	3	1304.37	100
1247.5		SiII	8	1246.738	100	1304.45		SiII	3	1304.37	100
1249.2	1.5	SiII	13.05	1250.09	150	1305.15		OI	2	1306.03	200
1249.6				1250.09	100	1307.85	1.6	SiII	3	1309.28	200
1250.0		SiII	1	1250.50	300	1308.2					
1250.7	0.2	SiII	1	1250.50	300	1308.6					
1252.4	1.5	SiII	1	1253.79	500	1310.0		PII	2	1310.70	600
1252.9						1312.5		?			
1253.3						1315.75	1.2	NiII	10	1317.220	500
1253.9	0.2	SiII	1	1253.79	500	1316.4					
1259.0	2.4	SiII	4	1260.42	500	1316.8					
		SiII	1	1259.53	500	1317.35	0.1	NiII	10	1317.220	500

TABLE 2 (continued)

I D E N T I F I C A T I O N S						I D E N T I F I C A T I O N S					
λ obs. (Å)	FWHM (Å)	ELEMENT	MULT.	λ lab. (Å)	INT.	λ obs. (Å)	FWHM (Å)	ELEMENT	MULT.	λ lab. (Å)	INT.
1335.8	0.2	CII	1	1335.71	1000	1498.0		TiIII	3	1498.70	600
1343.7		PIII	1	1344.34	1000	1498.75		TiIII		1499.173	300
		PIII	1	1344.90	650	1499.6		NiII	7	1500.651	200
1346.4		SiII	7	1346.873	100	1501.4		PIII	6	1501.55	700
1347.35		SiII	7	1348.54	100			PIII	6	1302.27	1000
1347.85								TiIII		1502.311	200
1348.15						1503.5		PIII	6	1504.72	900
1349.5		SiII	7	1350.057	150			TiIII		1504.621	120
1352.2		SiII	7	1352.635	100	1504.4		FeIII	85	1505.166	650
1353.15		SiII	7	1353.718	100	1509.6		NiII	6	1510.859	75
1358.45		?									
1360.45		FeII		1361.372	85	1510.0					
1360.95		SiIII	46	1361.597	160	1510.4					
		NiII		1361.885	50	1525.15	1.5	SiII	2	1526.71	500
1362.5		SiIII	38	1363.459	140	1525.6					
1363.6		FeII	103	1364.575	240	1526.05					
1364.0						1526.8	0.3	SiII	2	1526.71	500
1366.0		SiIII	46	1367.049	140	1532.3	1.7	SiII	2	1533.43	1000
1367.5		FeII		1368.098	50	1537.5		FeIII	84	1538.632	650
1368.8	0.8	NiII	8	1370.136	500	1538.1		FeIII	84	1539.128	550
1369.3									84	1539.480	300
1369.5						1549.7	6.1	CIV	1	1548.19	1000
1370.2	0.15	NiII	8	1370.136	500			CIV	1	1550.77	950
1371.85		FeII	85.07	1372.292	6 J	1558.1		FeII	45	1559.084	400
1373.3		NiII	9	1374.075	150	1558.55		FeII	46	1558.542	200
1374.2		FeII		1375.172	200			FeII	46	1558.690	200
1374.7						1560.5		CI	3	1560.68	500
1378.9		PIII	7	1379.87	500			CI	3	1560.71	200
1380.15		PIII	7	1380.46	1000	1560.9		CI	3	1561.44	1000
1380.55		PIII	7	1381.11	1000	1561.5		FeII	68.01	1562.270	4 J
1380.85		PIII	7	1381.63	800	1561.9					
		NiII	8	1381.295	200	1562.8		FeII	45	1563.79	500
1393.6	4.1	SiIV	1	1393.76	1000	1563.2					
1398.3		NiII	8	1399.026	80	1565.8		FeII	44	1566.82	400
1402.6	3.7	SiIV	1	1402.77	800	1566.35					
1405.1		?				1568.6		FeII	44	1569.67	240
1407.9		FeII		1408.478	80	1569.2		FeII	45	1570.25	400
1409.8		NiII		1411.071	100	1569.7					
1410.25						1573.4		FeII	44	1574.77	400
1410.6						1573.8		FeII	45	1574.93	400
1412.1		FeII	60	1413.699	70	1576.4		FeII	45	1577.166	20
1412.4		FeII	46.07	1412.867	8 J	1576.7					
		FeII	47	1412.842	8 J	1577.6		FeII	68.01	1578.219	2 J
1413.7		?				1577.8					
1415.0		NiII		1416.06	12	1579.6		FeII	44	1580.625	500
		NiII		1415.73	20	1580.0					
1416.9	1.7	FeII	143	1417.744	400	1584.0		FeII	44	1584.95	300
1419.8		TiIII		1420.036	300	1584.4					
		TiIII		1420.440	280	1585.5		FeII		1585.985	30
1420.7		TiIII		1421.631	280	1587.2		FeII	44	1588.286	200
1421.2		TiIII		1421.767	250	1587.5					
1421.7		TiIII		1422.405	650	1597.7		ScIII	1	1598.002	160
1423.7		FeII	47	1424.716	70	1601.4		FeIII	119	1602.00	300
		FeII	47	1424.047	50	1602.0		ScIII	1	1603.064	360
		TiIII		1424.140	300	1604.8		NiII		1605.910	60
1429.85		FeII		1430.780	200	1605.3		FeIII		1606.014	200
1430.5		FeII		1430.895	120	1606.6		FeIII	118	1607.723	600
1434.3		FeII	47	1434.996	70	1607.35	1.1	FeII	8	1608.456	700
1446.0	4.0	?				1607.85					
1453.3		TiIII	5	1455.19	1000	1608.6	0.2	FeII		1608.456	700
1454.0		NiII	7	1454.852	200	1610.0		FeII	43	1610.923	300
1454.4										1610.933	300
1455.9		NiII		1456.913	16	1611.9		FeII	43	1612.81	400
1464.15		FeII	193	1465.043	400	1612.2					
1464.5						1613.5		NiII		1614.911	90
1466.4		NiII	6	1467.762	100	1614.0		NiII		1615.459	120
1466.6						1614.4					
1466.85						1615.8		NiII		1617.088	50
1468.0		NiII	6	1467.762	100	1616.2		NiII		1617.144	40
1485.6		FeIII	85	1486.265	450	1616.8		NiII		1617.299	40
1491.85		NI	4	1492.64	620	1617.5		FeII	8	1618.47	500
1492.05		NI	4	1492.82	100	1617.9					
		FeIII	85	1493.640	600	1620.7	1.0	FeII	8	1621.685	600
1493.9		NI	4	1494.68	400	1621.1					
		FeII	316.04	1494.776	3 J	1622.15		FeII	43	1623.091	160
1494.3		FeIII		1495.210	70	1622.5					
		NiII		1495.383	40	1623.7		FeIII		1624.206	150

TABLE 2 (continued)

I D E N T I F I C A T I O N S						I D E N T I F I C A T I O N S					
λ obs. (A)	FWHM (A)	ELEMENT	MULT.	λ lab. (A)	INT.	λ obs. (A)	FWHM (A)	ELEMENT	MULT.	λ lab. (A)	INT.
1624.5	1.0	FeII	43	1625.520	400			NiIII	16	1715.303	650
1624.9		FeII	8	1625.909	300	1715.4		FeII	39	1716.577	40
1625.3		AlII	9	1625.627	150	1716.0					
1628.1		FeII	8	1629.154	600	1717.2		FeII	38	1718.123	40
1628.5						1717.5					
1630.1		FeII	8	1631.12	600	1718.6		NiIII	16	1719.458	500
1630.45						1719.4		FeII	38	1720.621	400
1631.5		FeII	43	1632.667	20	1719.6		FeII	84	1720.042	200
1631.8		NiIII	17	1632.166	100	1720.1		AlII	6	1721.27	900
1632.0		NiII		1632.171	30	1720.4		AlII	6	1721.24	500
1632.8	FeII	43	1633.908	300			CII	14.02	1721.68	200	
1633.4	FeII	8	1634.345	400					1721.01	100	
1633.7					1722.0		FeIII		1722.837	250	
1634.4	FeII	68	1635.398	700	1724.1	1.2	AlII	6	1724.98	900	
1634.8									1724.95	500	
1635.15	FeII	8	1636.321	600			FeII	37	1724.966	160	
1635.7					1725.3		FeII	39	1724.854	160	
1636.4	FeII	42	1637.397	300	1725.75		FeII	38	1726.391	240	
1636.9	NiII		1637.589	300	1730.0						
	NiII		1637.439	100	1730.4		FeII	110	1731.038	200	
1638.35	FeII	8	1639.403	600	1737.1						
1638.85					1737.8		NiIII	15	1738.252	500	
1639.5	FeII	43	1640.150	240	1740.1	1.1	NiIII	28	1738.785	300	
1640.6	FeII	68	1641.76	500	1740.5		NiII	5	1741.547	1000	
1641.1					1740.8						
1642.6	FeII	42	1643.576	300	1741.7		NiII	5	1741.547	1000	
1643.0					1746.2		NiIII	15	1747.011	550	
1645.2	FeII	68	1646.182	400	1746.7		NiII	5	1748.285	500	
1645.6					1747.2						
1646.1	FeII	68	1647.159	500	1747.7						
1646.6					1750.4	1.1	NiII	4	1751.911	300	
1648.5	FeII	68	1649.572	400	1750.7						
1649.0	FeII	42	1649.426	300	1751.2						
1653.5	FeII	68	1654.105	100	1752.0		NiII	4	1751.911	300	
1653.9	FeII	42	1654.476	100	1753.7		NiII	4	1754.808	50	
1656.4	CI	2	1656.27	350	1759.3		AlII	5	1760.10	350	
	CI	2	1656.93	300			FeII	100	1760.415	400	
1657.1	CI	2	1657.01	1000	1760.2		FeII	101	1761.379	500	
1657.6	CI	2	1657.38	300	1761.0		AlII	5	1761.98	300	
1658.2	FeII	40	1659.487	400	1763.1		AlII	5	1763.95	700	
1658.9									1763.87	500	
1660.6	FeII	41	1661.347	5 J	1764.0		NiIII	14	1764.688	800	
1662.1	FeII	40	1663.221	300	1765.0		AlII	5	1765.82	300	
1662.6					1766.9		AlII	5	1767.73	400	
1669.5	1.6	AlII	2	1670.787	1000	1769.0		NiIII	14	1767.938	500
		FeII	40	1670.742	500	1769.3		NiIII	14	1769.643	1000
1670.9	0.3	AlII	2	1670.787	1000	1769.8		FeIII		1770.247	200
1672.4		FeII	102	1673.462	300	1770.35		FeIII		1770.554	400
1672.9					1771.3		NiIII	14	1771.492	100	
1673.8	FeII	40	1674.716	80	1771.5		FeIII		1771.975	150	
1674.1	FeII	41	1674.440	40	1771.85		FeII	99	1772.509	300	
1676.0	FeII	41	1676.853	20	1772.8						
1678.3	FeII	102	1679.381	300			NiII	3	1773.949	25	
1678.7					1775.1		NiIII	27	1773.788	40	
1680.5	FeII	40.01	1681.111	1 J			FeIII		1775.983	400	
1685.4	FeII	40	1686.455	160	1780.6		NiIII		1776.068	400	
1685.9					1782.2		FeII	67	1781.702	40	
1687.3	NiIII	25	1687.897	400	1784.05	1.0	NiIII	14	1782.747	60	
1691.9	NiIII	16	1692.514	1000	1784.6		FeII	191	1785.26	800	
1694.2	FeIII		1695.036	150	1785.75	1.0	FeII	191	1786.74	800	
1695.65	FeII	38	1696.794	160	1786.15						
1696.15					1787.0	1.0	FeII	191	1788.07	700	
1698.0	FeII	85	1699.193	40	1787.4		NiII	5	1788.485	100	
1700.9	FeII	38	1602.045	500	1790.5		NiIII	14	1791.644	200	
1701.45					1792.3		FeII	99	1793.367	200	
1702.3	NiII	5	1703.408	25	1792.7						
1702.6	NiIII	16	1703.467	50	1794.2		NiIII	14	1794.904	200	
1702.9					1797.3		FeII	142	1798.150	200	
1703.6	NiII	5	1703.408	25	1806.0	1.3	SIII	1	1808.01	150	
1706.8					1806.8						
1707.6					1807.2						
1708.0	NiII	4	1709.598	200	1808.2	0.25	SIII	1	1808.01	150	
1708.6	FeII	84	1709.670	300	1810.9		FeIII		1811.924	200	
1709.05	NiIII	16	1709.901	800	1811.2				1811.689	200	
1709.8	NiII	4	1709.598	200	1811.4		NiII	24	1812.065	30	
1714.5	FeII	84	1715.503	240							

TABLE 2 (continued)

IDENTIFICATIONS						IDENTIFICATIONS					
λ obs. (Å)	FWHM (Å)	ELEMENT	MULT.	λ lab. (Å)	INT.	λ obs. (Å)	FWHM (Å)	ELEMENT	MULT.	λ lab. (Å)	INT.
1814.85	1.9	SiII	1	1816.93	200	1950.0		FeIII	68	1951.007	800
1815.6										1951.318	200
1816.1						1952.0		FeIII	68	1953.322	900
1821.2						1962.3		FeII	170	1963.110	500
1821.5						1963.5		FeIII	82	1964.169	550
1822.0										1964.776	550
1829.7		FeIII	117	1830.623	200					1964.019	300
		NiIII	20	1830.006	400					1964.260	450
			20	1830.075	200					1964.342	240
1831.0		?				1964.2		FeII	170	1964.342	240
1832.9		FeIII		1834.096	70	1975.3	1.4	FeIII	106	1965.309	550
1834.5		FeII	98	1835.874	300	1977.6		FeIII	54	1976.126	550
1834.9						1979.3		FeIII	54	1978.417	250
1837.5		FeIII	117	1838.309	450	1981.4		FeIII	54	1982.076	400
1840.5		FeII	65	1841.701	200	1992.3		FeIII	50	1993.262	450
1840.9								ScIII	4	1993.886	180
1842.9		FeIII	117	1843.502	150	1993.2		FeIII	50	1994.073	900
1844.3		FeIII	117	1845.304	300	1994.0		FeII	228	1994.857	400
			97	1845.521	450			FeIII	50	1995.266	450
1845.9		FeII	98	1846.573	240					1995.563	800
1846.5		NiIII	19	1847.275	650	1995.5		FeIII	50	1996.420	800
1853.6		AlIII	1	1854.716	1000	1998.8		FeII	187	1999.430	200
		FeIII	63	1854.826	600	1999.6		FeII	186	1999.462	150
				1854.975	300	2000.3		FeIII	55	2001.167	25
		NiIII	19	1854.149	800	2003.4		NiII	33	2004.266	50
1855.9		FeIII	63	1856.690	450	2005.0		FeIII	55	2006.265	25
1857.4		FeIII	63	1858.542	300	2006.3		FeIII	55	2007.845	90
1859.1		FeIII	63	1859.955	200			FeII	83	2007.452	150
		FeII	65	1859.741	300					2007.013	120
		FeII	97	1860.055	400	2007.6		FeIII	55	2008.469	40
1861.5		AlIII	1	1862.790	600			FeII	83	2008.358	
		AlII	4	1862.311	1000					2008.090	
1862.6		AlIII	1	1862.790	600	2024.8	1.5	ZnII	1	2025.486	300
1864.1		FeII	126	1864.743	400			MgI	2	2025.824	35
1865.5		FeIII	52	1866.305	600	2026.3		FeII	186	2027.778	50
1869		FeIII	52	1866.554	300	2026.6					
1870.3		FeIII	52	1869.828	650	2028.6		FeII	93	2029.182	80
1871.7		FeIII	52	1871.152	600	2029.1					
		FeIII		1872.214	400	2031.9		FeII	94	2032.407	250
		FeIII		1872.52	250	2032.3					
1881.35		FeIII	62	1882.047	650	2036.2		?			
1883.8		FeIII	96	1885.125	600	2055.7		FeIII	71	2056.145	120
		FeIII	62	1884.596	550	2061.0		ZnII	1	2062.003	300
1885.8		FeIII	52	1886.757	800			CrII	1	2061.54	175
1886.4		FeIII	52	1887.471	550			FeIII	48	2061.552	250
		FeIII	53	1887.197	550	2062.4		ZnII	1	2062.003	300
1889.6		FeIII	52	1890.669	900	2062.85		FeII	92	2063.672	250
1891.1		FeIII	96	1892.247	300	2067.25	2.7	FeIII	48	2068.243	350
				1892.073	300	2089.5		FeIII	67	2090.139	350
		FeIII	52	1892.140	300	2090.8		FeIII	77	2091.312	120
1894.0		FeII	34	1895.46	1000	2092.9		FeII	290	2093.711	50
		FeII	124	1895.675	200	2093.25					
1896.0		FeIII	83	1896.803	600	2097.0		FeIII	67	2098.149	570
1898.1		FeIII	96	1899.318	300				66	2098.361	350
1906.9		FeIII	83	1907.577	650			FeII	120	2098.176	250
				1907.741	250	2160.3		NiII	14	2061.217	80
1909.7		FeIII	57	1910.401	400	2164.3		NiII	13	2165.55	320
1912.7		FeIII	57	1913.622	250	2168.0		NiII	13	2169.096	440
		FeIII	34	1914.056	1000	2173.5		FeIII	70	2174.658	570
1916.7		FeIII	101	1917.453	600			NiII	14	2174.666	440
			95	1917.351	550	2176.25		NiII	40	2177.086	220
			108	1917.087	150					2177.361	200
		FeII	96	1917.337	300	2179.3		NiII	40	2180.473	280
1917.4		FeIII	108	1918.480	450			FeIII	70	2180.410	350
			57	1918.284	450	2183.5		NiII	13	2184.60	280
1919.0		FeIII	95	1920.186	250	2200.2		NiII	13	2201.409	240
1921.9		FeIII	51	1922.79	1000	2205.5		NiII	13	2206.715	620
			95	1923.003	450	2209.0		NiII	13	2210.382	180
		FeII	138	1922.797	400	2215.0		NiII	12	2216.482	800
1924.7		FeII	123	1925.983	400	2219.3		NiII	28	2220.402	280
1936.3	1.8	FeIII	51	1937.34	950	2221.6		NiII	12	2222.957	300
		FeII	96	1936.799	400	2243.2		?			
1938.2		FeIII	106	1938.901	650	2252.5		NiII	12	2253.848	220
1939.25		FeIII	61	1940.018	550	2263.5		NiII	12	2264.461	320
1940.7		FeIII	79	1941.633	200	2268.7		NiII	12	2270.214	440
1942.5		FeIII	51	1943.48	950	2269.5					
1944.4		FeIII	61	1945.342	800	2275.0		NiII	39	2275.684	180

TABLE 2 (continued)

I D E N T I F I C A T I O N S					I D E N T I F I C A T I O N S						
λ obs. (A)	FWHM (A)	ELEMENT	MULT.	λ lab. (A)	INT.	λ obs. (A)	FWHM (A)	ELEMENT	MULT.	λ lab. (A)	INT.
2277.6		NiII	22	2278.770	280	2460.3					
2286.0		NiII	38	2287.648	220	2461.1		FeII	209	2461.860	100
			22	2287.089	180	2462.5					
2295.5		NiII	21	2296.552	200	2463.5		FeII	208	2463.292	50
2297.5		NiII	21	2298.270	180	2464.25		FeII	208	2464.009	40
2298.9		NiII	27	2299.651	140	2465.2		FeII	148	2465.199	10
2301.9		NiII	11	2302.996	320	2466.0		FeII	208	2465.912	50
			59	2302.479	140	2471.6		FeII	179	2466.819	60
2307.7		NiII	50	2308.518	120	2472.2		NiII	19	2473.148	100
2311.4		NiII	58	2312.916	140	2478.7					
2314.4		NiII	11	2316.039	320	2479.4		FeII	179	2480.115	285
2318.0		NiII	37	2319.750	220	2480.9					
2326.0		FeIII	121	2326.948	250			FeII	207	2482.657	100
2331.4		FeII	3	2332.80	170	2481.45					
2333.1		NiII	20	2334.524	220	2482.8		NiII	61	2484.204	140
2336.7		FeII	3	2338.007	140	2483.4					
2337.8						2485.05		FeII	208	2486.343	220
2340.0		NiII	50	2341.202	220	2485.55					
2342.0		FeII	3	2343.494	240	2488.5		FeII	331	2490.706	100
2343.4		FeII	3	2344.281	125	2489.2					
2343.8						2490.05		FeII	207	2491.396	100
2347.0		FeII	36	2348.113	140	2490.6					
			3	2348.299	155	2491.7		FeII	161	2493.262	220
2350.5		FeII	379	2351.666	15	2492.4					
2353.6		FeII	165	2354.477	50	2497.25		FeII	161	2498.897	450
2358.4		FeII	3	2359.118	140	2498.05					
			165	2359.111	285	2502.2		FeII	161	2503.560	110
			379	2359.118	140	2503.0					
2359.0		FeII	35	2359.997	125	2505.0		NiII	48	2505.843	120
2359.4			36	2360.293	110	2509.4		NiII	18	2510.871	220
2363.4		FeII	3	2364.826	140	2510.1		FeII	161	2511.761	110
2364.0						2510.9					
2372.2		FeII	2	2373.735	125	2513.75		NiII	61	2514.627	140
2373.0						2514.9		?			
2374.0		NiII	21	2375.418	320	2515.2		TiIII	7	2516.053	1000
2378.4		FeII	3	2380.762	110	2515.65		?			
2379.3						2516.5					
2380.5		FeII	2	2382.03	320			FeII	147	2517.131	50
2381.3									207	2517.211	20
2382.3		?				2518.25		FeII	268	2519.046	60
2387.0		FeII	2	2388.63	170	2520.4		FeII	268	2521.092	40
2387.7						2521.1			330	2521.816	30
2393.6	2.7	FeII	2	2395.63	320	2523.6		FeII	159	2525.388	140
2394.7						2524.5		NiII	61	2525.296	180
2397.7	1.5	FeII	2	2399.241	170	2528.0		FeII	177	2529.549	155
2398.5						2528.7					
2403.4		FeII	2	2404.88	280	2532.0		FeII		2533.627	110
2405.0		FeII	2	2406.660	155	2532.8					
2405.9						2535.1		FeII	159	2536.803	140
2409.4		FeII	2	2410.52	170	2536.1					
2411.95		FeII	2	2413.310	125	2537.2		FeII	158	2538.799	100
2412.6						2538.1				2538.909	100
2414.9		NiII	20	2416.134	440					2538.993	125
2422.3		FeII	301	2423.210	40	2544.4		NiII	18	2545.903	140
2427.6		FeII	300	2428.364	110	2545.0					
2428.5		FeII	180	2430.078	110	2548.0		FeII	145	2548.74	100
2429.3						2554.0		NiII	62	2554.988	140
2431.0		FeII	180	2432.262	80	2556.25		ZnII	3	2557.947	1000
2431.5			164	2433.495	70	2558.9		NiII	62	2560.156	120
2432.1		NiII	19	2433.556	100	2561.0		FeII	64	2562.54	200
2433.3		FeII	321	2434.729	50	2561.7					
2434.1			375	2434.822	50	2562.6		FeII	2563.47		140
			180	2434.951	50	2565.4		FeII	64	2566.91	60
2436.4		NiII	19	2437.892	220	2566.1					
		FeII	375	2437.632	200	2567.8		?			
2437.5		FeII	209	2439.302	125	2569.3		?			
2438.6						2570.0		?			
2443.8		FeII	375	2444.274	100	2572.8		FeII	144	2574.362	125
			148	2444.515	100	2573.55					
2449.4		FeII	375	2450.134	50	2575.25		MnII	1	2576.105	1000
			300	2450.205	25	2577.1		FeII	64	2477.92	60
2453.2		FeII	2453.935	250	2580.95		FeII	64	2582.580	100	
2453.9						2581.8					
2457.3		FeII	209	2458.784	125	2584.2	1.7	FeII	1	2585.876	750
2458.1						2585.0					
						2586.2	0.5	FeII	1	2585.876	750

TABLE 2 (continued)

IDENTIFICATIONS						IDENTIFICATIONS					
λ obs. (Å)	FWHM (Å)	ELEMENT	MULT.	λ lab. (Å)	INT.	λ obs. (Å)	FWHM (Å)	ELEMENT	MULT.	λ lab. (Å)	INT.
2590.0 } 2590.8 } 2592.3 } 2592.9 } 2594.15 } 2597.5 }	2.7	FeII	64	2591.54	450	2751.6 } 2752.5 } 2754.0 } 2754.8 }		FeII	235	2753.287	80
		FeII	64	2593.722	220	2760.25 } 2761.0 }		FeII	62	2755.73	280
	0.5	?				2765.8 } 2766.6 }		FeII	63	2761.812	125
		FeII	1	2599.395	870			FeII	235	2767.50	750
2599.75 } 2605.2 } 2606.0 } 2610.1 } 2611.0 } 2612.5 } 2613.05 } 2616.0 } 2616.85 } 2619.85 }		FeII	1	2598.37	870			FeII	373	2767.500	750
		FeII	1	2599.395	870	2767.5 } 2768.3 }		FeII	63	2768.934	12
		FeII	1	2607.09	750	2777.3 } 2777.75 }		FeIII	2778.868		60
		FeII	1	2611.87	240	2778.4 }		FeII	234	2779.299	40
		FeII	1	2613.82	750	2782.0 }		FeII	234	2783.691	50
		FeII	2617.62		650	2782.7 }					
		FeII	1	2620.41	12	2789.4 }	1.3	MgII	3	2790.771	150
		FeII	1	2621.669	40	2793.3 }		MgII	1	2795.523	400
		FeII	1	2621.67	40	2795.9 }	0.6	MgII	1	2795.523	400
		FeII	1	2625.667	140	2800.5 }		MgII	1	2802.698	300
		FeII	1	2628.293	125	2803.1 }	0.5	MgII	1	2802.698	300
		FeII	1	2631.322	155	2830.0 }		FeII	217	2831.561	25
		FeII	1	2631.047	155	2830.8 }		CrII	5	2835.63	200
		CrII	8	2663.42	75	2834.4 }		CrII	82	2840.01	85
		CrII	8	2666.02	80	2839.0 }		FeII	294	2843.485	110
		FeII	283	2684.754	220	2841.9 }		CrII	5	2843.24	100
		CrII	84	2692.11	25	2842.4 }		FeII	317	2848.899	110
		FeII	159	2701.13	220	2842.7 }					
		FeII	261	2703.988	60	2847.15 }	0.3	CrII	5	2849.83	100
		FeII	341	2706.566	220	2847.7 }		FeIII	155	2850.288	120
		CrII	7	2712.30	80	2848.2 }		MgI	1	2852.127	1000
		FeII	63	2714.41	80	2849.0 }		MgI	1	2852.127	1000
		FeII	261	2716.217	50	2850.7 }		CrII	5	2855.67	100
		FeII	339	2716.429	40	2852.5 }		CrII	5	2858.91	75
		FeII	389	2719.301	12	2854.7 }				2858.655	30
		FeII	63	2736.98	650	2857.5 }		CrII	5	2866.72	100
		FeII	63	2739.54	200	2865.6 }		CrII	5	2867.65	100
		FeII	62	2743.20	140	2866.1 }		CrII	11	2880.86	75
		FeII	63	2746.98	870	2866.8 }		FeIII	125	2895.076	150
		FeII	62	2746.483	170	2867.2 }		FeII	60	2926.586	10
		FeII	63	2749.18	750	2879.1 }	1.4	MgII	2	2928.635	80
		FeII	63	2749.48	220	2879.8 }		MgII	2	2936.501	100
						2893.65 }		FeII	78	2847.66	750
						2924.8 }		FeII	60	2953.774	550
						2925.7 }					
						2927.4 }					
						2935.2 }					
						2945.9 }					
						2946.7 }					
						2952.0 }					
						2952.9 }					
						2963.4 }					
						2968.9 }					
						2983.1 }					
						2983.9 }					
						3000.85 }					
						3001.7 }					

The behaviour of the different elements and ions can be summarized as follows:

C I: The lines present are sharp, undisplaced, resonance lines (Fig. 1).

O I: This element is present in the resonance lines of multiplet 2 but they are blended with Si II; one can say for certain that O I displays relatively broad and also sharp components, and that its behaviour is definitely different than that of C I.

Mg II: The resonance lines (multiplet 1) display a P Cygni profile, the broad violet

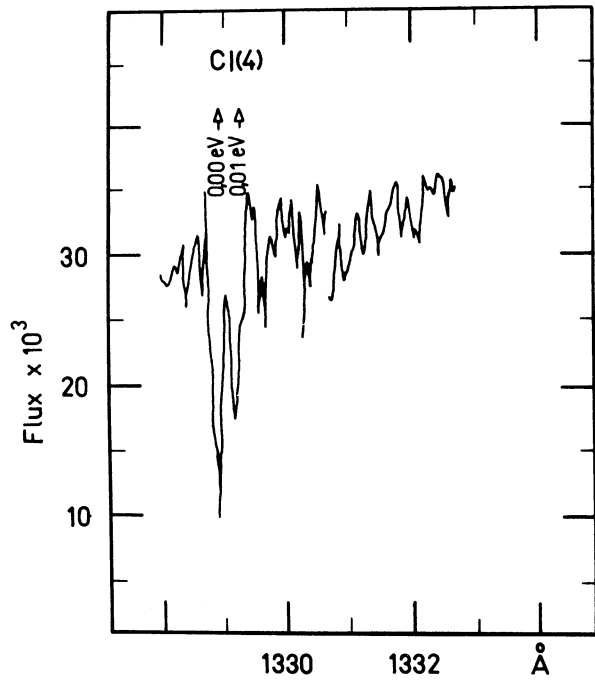
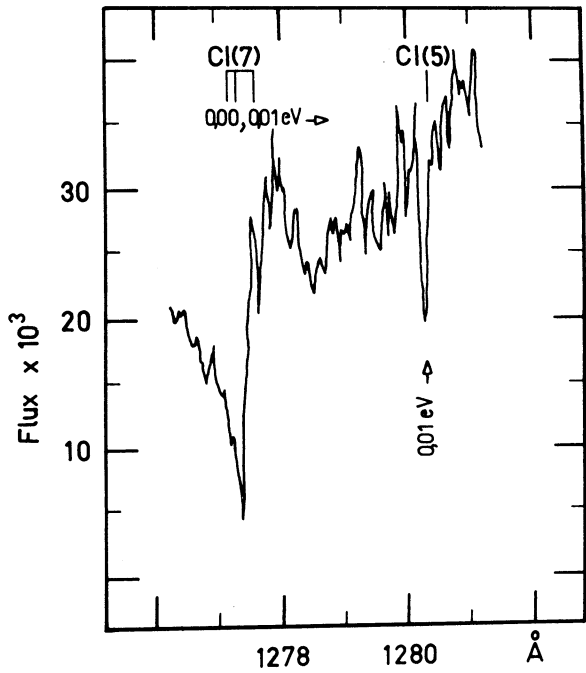


Fig. 1. The resonance lines of C I.

absorption ($\text{FWHM} \sim 3\text{\AA}$) being displaced by about -230 km/s. Actually, this absorption is very broad and we may be dealing with at least 2 components with velocities of approximately -300 and -175 km/s, respectively, values which in view of the uncertainties involved, could be considered similar to those from the absorption components in the photographic region. In addition, there is a sharp absorption at about $+40$ km/s. Subordinate lines of Mg II would seem to display two relatively broad absorption components. Figure 2 shows the resonance lines of Mg II.

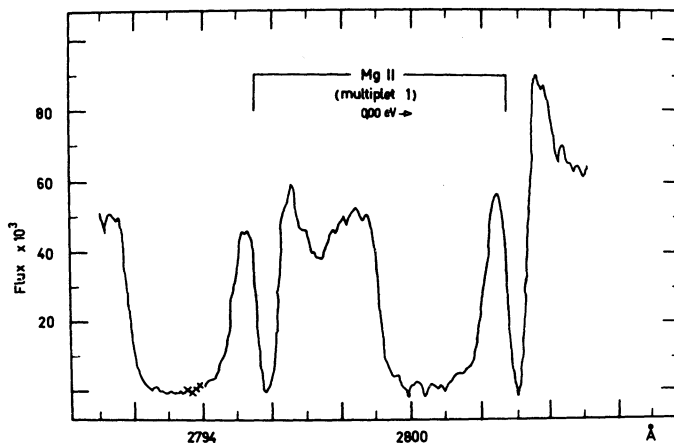


Fig. 2. The resonance lines of Mg II.

Al II: This ion displays a broad absorption feature ($\text{FWHM} \sim 1.2\text{\AA}$) at -120 km/s the lines arising from 0.00 eV level also display a sharp absorption at about $+20$ km/s.

Si II: Singly ionized silicon displays three components, a sharp one at about -300 km/s and two broad ones at -200 and at -120 km/s; the lines that arise from 0.00 eV level display, in addition, a sharp absorption at about $+30$ km/s (Fig. 3).

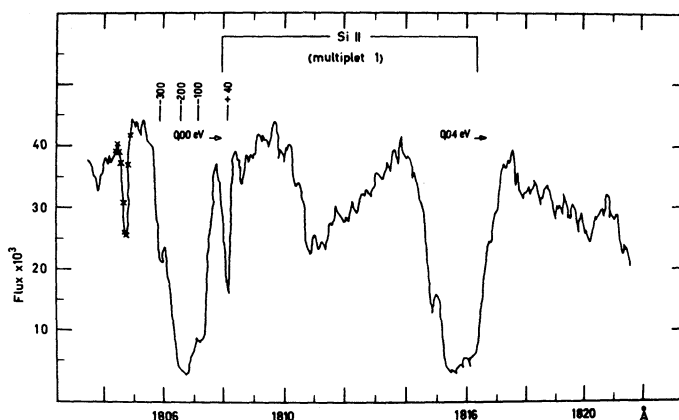


Fig. 3. The behaviour of Si II, multiplet 1.

S II: Singly ionized sulphur behaves like Si II.

Cr II: The lines of this ion are poorly defined; however, their behavior appears to be similar to that of Fe II.

Fe II: This ion displays two broad components at -200 and at -100 km/s; the lines arising from 0.00 eV level also display a sharp absorption at about $+35$ km/s (Fig. 4).

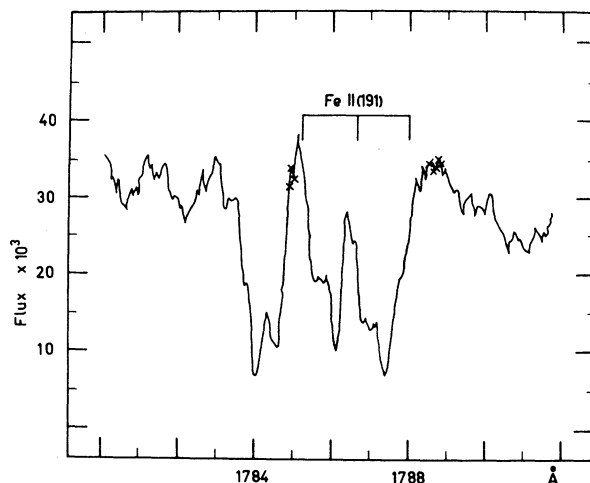


Fig. 4. Lines of Fe II.

Ni II: Singly ionized nickel displays three components, a sharp one at about -275 km/s and two broad ones at about -200 and -100 km/s, respectively; the resonance lines also display a sharp $+25$ km/s component (Fig. 5).

P III, Ti III, Fe III, Ni III: These ions display a single profile, with FWHM ~ 1.4 Å, at about -200 km/s (Fig. 6). Ti III from 0.00 eV level displays also a sharp component at about $+45$ km/s; we cannot tell whether the same is true with the P III lines that arise from 0.00 eV level because they coincide with the resonance lines (multiplet 1) of C II. Fe III and Ni III have no resonance lines in the IUE wavelength range.

N V, C IV: These two ions display the two resonance components of multiplet 1, with apparently the same structure as the resonance lines of Si IV.

Si IV: Triply ionized silicon displays the two resonance lines of multiplet 1 and each one seems to show two relatively broad components at -200 and at $+120$ km/s. The latter measurement depends on the interpretation of the overall profile and, therefore, it is uncertain however, the actual value would seem to be, in any case, positive, and, as a consequence, in Table 3 we have entered the velocity value of $+120$ km/s for such a component, the profile of which may be asymmetric towards the longer wavelengths (Fig. 7).

Table 3 presents a summary of the behavior, velocity-wise, of the different elements and ions.

IV. DISCUSSION

Our study of the two IUE images of AX Mon shows conclusively that there is no contribution to the UV spectrum from the K component of the system and that no photospheric lines of the B companion appear to be present. Therefore, the UV line spectrum arises exclusively in the extended envelope in which the system is embedded.

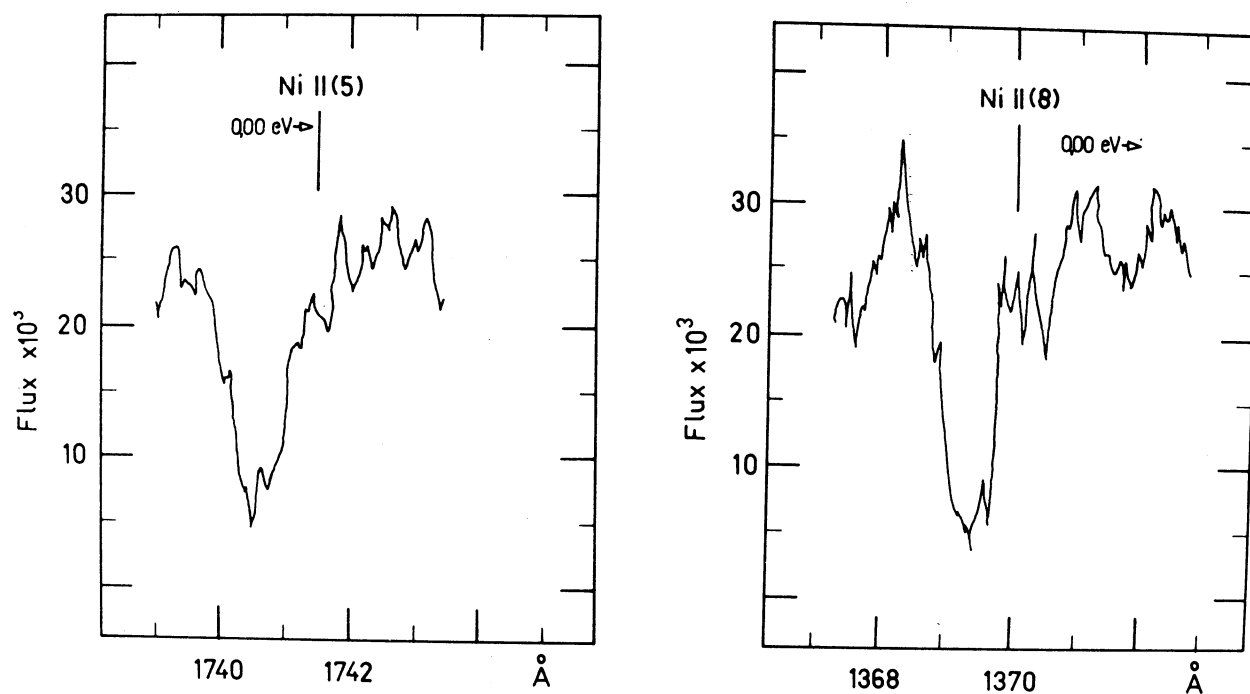


Fig. 5. The resonance lines of Ni II.

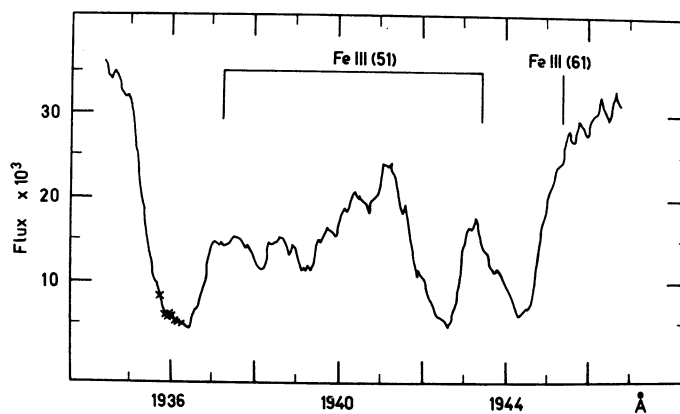


Fig. 6. Lines of Fe III.

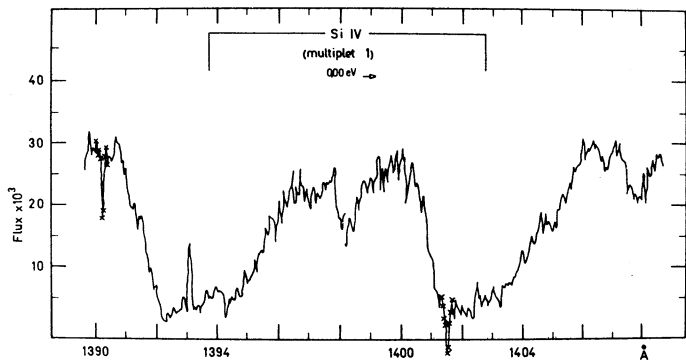


Fig. 7. The resonance lines of Si IV.

TABLE 3
VELOCITY BEHAVIOR OF SPECTRAL ABSORPTION LINES IN AX MONOCEROTIS

Element/Ion		Radial Velocity (in km/s)						
IUE	Photo-graphic	sharp comp.	Resonance Lines sharp components (0.00-0.01 eV)					
(H)	H*	-250	-150					
C I							0	
C IV					x			x
N V					x			x
O I					x:			x
	Na I				x	x	+6? +23	
Mg II*				-250:	-150:			+40
Al II			x					+40
Si II		-300	-200	-100	-300	-200	-100	+40
Si IV						-200		+120
P III			-200					
S II		-300	-200	-100	-300	-200	-100	+40
	Ca II				x	x	+6? +24	
Ti III			-200					
Cr II			x	x				x
Fe II			-200	-100		-200	-100	+40
Fe III			-200					
Ni II		-250	-170	-100				+40
Ni III			-200					

* P Cygni profiles. The velocities correspond to the violet absorptions.
x indicates probably present.
Figures derived from the photographic region were taken from Cowley (1964).

What can we conclude from observations that correspond to only one phase in the orbital cycle, namely, about 0.38P, counted from the conjunction at which the K star is in front?

1. Non-Thermal Sources

In the first place, we note that in AX Mon, as it has been true in other binary systems (Sahade and Ferrer 1982, Sahade and Hernández 1984a, b) and in symbiotic objects (Sahade, Brandi and Fontenla 1984), the line spectrum corresponds to a large range in electron temperature and some of these temperatures, like those that are required for the formation of the resonance lines of N V, C IV and Si IV, cannot be accounted for by the radiation field of either component of the system. This would suggest, here again, the existence of non-thermal sources of energy in the system.

2. High Electron Temperature Regions

In the second place, we have the fact that the resonance lines of Si IV display two broad components, one that yields a velocity of about -200 km/s and a second one that suggests a positive velocity. The existence of two components with very different velocities suggest, in turn, that there should be two regions of high electron temperature in the extended envelope of AX Mon. Because of the derived velocity values and because in other systems like β Lyrae (Hack *et al.* 1976) and AU Monocerotis (Sahade and Ferrer 1982) a similar conclusion has already been reached, we would be inclined to expect that the longward-displaced component of Si IV arises close to the stars, perhaps in the region where the gaseous stream from the K component interacts with the gaseous formation around the B-type companion (cf. Lubow and Shu 1975, Shu 1976). The asymmetry of this component towards long wavelengths, interpreted as indicating acceleration (Ringuelet 1983), would be an additional argument in support of our suggested location of the corresponding region of high electron temperature.

As far as the shortward-displaced component, we would like to suggest, also similarly as it was concluded in the cases of β Lyr (Hack *et al.* 1976), AU Mon (Sahade and Ferrer 1982) and γ_1 Velorum (Sahade and Hernández 1984a), that the corresponding high electron temperature region should be located at a certain distance from the stars and be perhaps related to the dissipation of shock waves produced in the area where gaseous matter is lost to the system through one of the external Lagrangian points (cf. Florkowski 1980). If we resort to the nomenclature used for the Sun, we can call *transition regions* the temperature-rise zones in the extended envelope of AX Mon where electron temperature increases at least up to the value required by the resonance lines of N V.

What about the rest of the lines?

3. The Interstellar Lines

The undisplaced resonance lines of C I must be of interstellar origin and, therefore, should be placed together with the interstellar lines of Ca II and Na I observed in the photographic region, outside the proper domain of the system.

4. The Outermost Layers of the Extended Envelope

The sharp component displayed by the resonance lines, arising in the 0.00 eV level, of O I, C II, Mg II, Al II, Si II, S II, Cr II?, Fe II, Ni II and Ti III, characterized by velocities in the range +20 to +40 km/s, should form in the outermost layers of the extended envelope. This is confirmed by the fact that H column density for Fe II comes out to be $6 \times 10^{19} \text{ cm}^{-2}$. However, the possibility exists that some of the lines that yield velocities of the order of +20 km/s, may be of interstellar origin.

5. The Cool Shell

Although we have no way, so far, of establishing a distance scale in the extended envelope of AX Mon we can still try to place the positions of the regions where other ultraviolet lines originate, relative to those we have already discussed.

The P Cygni profiles of H in the photographic region, of Mg II (1) in the ultraviolet, and the non-interstellar, non-shell-like lines of Ca II in the photographic region are normally considered to originate in the so-called *cool shell* (Doazan and Thomas 1982) where the temperature should be of the order of 10^3 and the electron density perhaps 10^4 or 10^5 cm^{-3} . In AX Mon we observe two components of the violet absorptions and the question arises as to whether both components originate in the *post-transition region*. This would be the simplest assumption and would imply that the smaller velocity component would form further out than the larger

6. The |Fe II| Region

If we follow the presently accepted sequence of atmospheric regions in extended envelopes of a variety of stars (cf. Doazan and Thomas 1982, Kuhi 1983), we would further place the region where $|\text{Fe II}|$ emission would originate, between the *cool shell* and the *outermost layers of the extended envelope*.

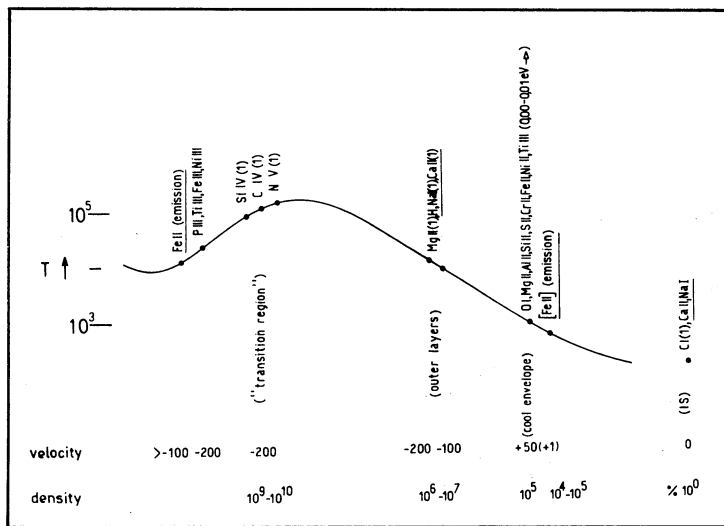


Fig. 8. Schematic model of the extended envelope of AX Monocerotis. The drawn temperature law curve and the distance scale are arbitrary. Information from the photographic region (Cowley 1964) is underlined.

Figure 8 depicts the location of the different regions we have mentioned, on an arbitrarily drawn temperature law curve, with an arbitrary distance scale. We still need to locate the region where the sharp component that is displayed by Si II, S II and Ni II at about -300 km/s originates from, the region of the subordinate lines of singly ionized elements, and also the region responsible for the lines of the doubly ionized elements. It is probable that the latter lines originate in the temperature-rise zone that precedes the *transition region*, and that the subordinate lines of singly ionized atoms form in a layer that is even closer in, but we need more information to ascertain whether all this is correct. Perhaps then we will be able to tell the relative location of the region where the photographic Fe II emission originates and whether such emission results from a geometrical or from a temperature effect (cf. Ringuet *et al.* 1984).

We have at disposal only one IUE image of AX Mon and, then, it seems impossible to go any further in modelling the extended envelope around the system. It would certainly be necessary to have a good coverage of the orbital cycle if we wished to confirm and/or to improve upon our proposal, and perhaps even to understand the discrepancy between the luminosity class suggested for the early-type component by the photographic spectrum and the luminosity class suggested by the ultraviolet continuum. At any rate, we can at least say that the binary AX Mon, in spite of its complicated spectrum, seems to lead to a model for its extended envelope that is quite similar to those for other interacting binaries. It is interesting to point out, however, that, in our case, the observations suggest, in terms of the model, the existence in the extended envelope of a velocity plateau at -200 km/s, over quite a range in electron density.

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