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Variability studies of Seyfert galaxies – II. Spectroscopy

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SUMMARY

Spectroscopic observations of 36 southern Seyferts are presented. Most of these also have been monitored photometrically over a period of four years (Winkler *et al.*). The objects are classified, line fluxes and widths are measured and peculiarities of the spectra are discussed. Many of the objects have been observed more than once and changes in the line strengths and profiles are examined. Comparisons are also made with the spectra published by other investigators.

Key words: galaxies: fundamental parameters – galaxies: photometry – galaxies: Seyfert.

1 INTRODUCTION

Important contributions have been made recently to our understanding of Seyfert galaxies as a result of intensive monitoring of the variations of these objects (e.g. Clavel, Wamsteker & Glass 1989; Clavel *et al.* 1991). Winkler *et al.* (1992, hereafter referred to as Paper I) used optical *UBVRI* aperture photometry to describe the continuum variations of 35 Seyfert galaxies over a period of four years. While the use of broad-band filters meant sacrificing spectral information, it allowed the bulk of the observing to be carried out with smaller, more easily available telescopes.

This paper describes the spectroscopic observations of 36 southern Seyfert galaxies, most of which were included in the photometric campaign described in Paper I (their names and positions are listed in Table 1 and in Paper I). Even though the Seyfert nature of most of the sample was not in doubt, it was decided to observe all these objects, partly because of the possibility of detecting spectral variations, but also because the spectra of many of the galaxies have not been described in much detail in the literature. This means that several properties of individual galaxies studied in Paper I may be uncertain. This paper sets out to determine the following parameters of the galaxies.

(i) The activity class. There are often conflicting reports in the literature about the activity of specific Seyfert galaxies. Sometimes even the Seyfert nature is in doubt. Véron-Cetty & Véron (1989) list 71 starburst galaxies that have in the past been misclassified as Seyferts.

(ii) The redshift, on which the estimate of the luminosity depends, was known for all but one of the galaxies in the sample.

(iii) The Balmer decrement. The value of the Hα-to-Hβ ratio can be used to estimate the reddening of the emission-line region. Alternatively, if the reddening is known through other considerations, the derived intrinsic Hα-to-Hβ ratio is a useful tool for testing models of the ionization mechanism.

(iv) The width of the broad lines. Line profiles are directly related to the dynamics of the line-emitting gas. Attempts have been made to resolve the lines into individual, usually Gaussian-shaped, components (Pelat, Alloin & Fosbury 1981), or to measure the asymmetry of the line profile (Whittle 1985). The most straightforward way to obtain information about the motion of the line-emitting region is to measure the linewidth at half maximum, this being a good indicator of the typical gas velocity.

(v) The luminosity of the broad-line region. A convenient way of quantifying this property is by measuring the luminosity of the Hβ line (Dahari & De Robertis 1988).

(vi) The luminosity of the narrow-line region. A parameter often used to describe this quantity is the luminosity of the [O III]5007-Å line (Dahari & De Robertis 1988).

(vii) The relative strength of the Fe II emission features. Photoionization models have not yet been able to explain the strong Fe II lines observed in many Seyfert galaxies (Collin-Souffrin & Lasota 1988).

2 OBSERVATIONS AND REDUCTIONS

Spectroscopic observations were made with the 1.9-m telescope at the South African Astronomical Observatory (SAAO), Sutherland, using the Grating Spectrograph with a RETICON photon counting array. A linear reflection grating with a dispersion of 210 Å mm^{-1} was used, which resulted in a spectral range of 3500–7300 Å. The slit width was normally 300 μm (=1.8 arcsec), leading to an effective resolution of about 7 Å. The slit length corresponded to 6.0 arcsec in the sky. An argon calibration spectrum was recorded before and after each integration. Integrations longer than 1200 s were interrupted in the middle in order to obtain a further calibration spectrum. Spectrophotometric standard stars from the lists of Stone & Baldwin (1983) and Baldwin & Stone (1984) were also observed in order to measure the system's response function.

The observations were made during several runs between 1986 November and 1990 August. Details are given in Table 2. Hβ and [O III] 5007-Å line fluxes were derived from spectra taken in photometric conditions with good seeing. All spectra were used to measure the relative line fluxes. The flux calibrated spectra are displayed in Fig. 1. Three objects not included in Paper I were also observed photometrically, their magnitudes and colours being given in Section 4 of this paper rather than in Paper I.

Table 1. The coordinates of the galaxies not observed in Paper I and the reddening within our Galaxy towards these.

Name	Other Names	R.A.(1950) h m s	Dec(1950) ° ′	$E(B\text{-}V)_g$ mag
1405.2-30	(Tol 20)	14 05 13	-30 09.7	0.06
Fairall 182	ESO 103-G56	18 38 37	-64 09.3	0.06
ESO 344-G16		22 11 45	-39 03.2	0.00
NGC 7314		22 33 00	-26 18.5	0.00

3 RESULTS

Variations in the spectra of the Seyfert galaxies observed never amounted to more than 20 per cent in the broad-line fluxes. The spectra for each galaxy were therefore co-added to improve the signal-to-noise ratio. The line fluxes and other spectral properties derived from these are given in Tables 3, 4 and 5 below.

The redshift, *cz*, was calculated from the narrow emission lines only. The measured fluxes were corrected for extinction in our Galaxy, using the formulae given by Miller & Mathews (1972), with $R=3.1$. For each object the reddening within our Galaxy, $E(B-V)_g$, given in Table 1 and Paper I, was estimated from the maps of Burstein & Heiles (1982). The Hβ and [O III] 5007-Å luminosities were evaluated assuming a Hubble constant of $H_0=50$ km s^{-1} Mpc^{-1}.

Table 2. Details of the spectroscopic observations. An 'x' indicates that the seeing was poor or that cloud was present.

Name	date dd-mm-yy	UT hhmm	time s	slit μm		Name	date dd-mm-yy	UT hhmm	time s	slit μm	
ESO 12-G21	29-07-87	0210	800	300		H 1143-182	12-01-88	0125	2400	300	
"	04-12-88	2125	1200	300	x	"	03-02-88	0040	2400	225	
"	05-12-88	2035	1200	300	x	MCG -2-33-34	04-03-87	2305	1000	300	
"	08-08-90	0010	1200	300	x	"	05-01-88	0145	2400	300	x
Ton S180	05-12-88	2000	2030	300		ESO 323-G77	04-03-87	2330	600	300	
NGC 526a	19-11-86	2030	1000	300	x	"	15-06-87	1810	600	225	x
"	30-07-87	0120	1000	300		"	12-01-88	0200	1200	300	
Fairall 9	18-11-86	1945	2000	300		MCG -6-30-15	04-03-87	2345	1000	300	
"	16-06-87	0400	1200	225	x	"	15-06-87	1830	1200	225	x
"	29-07-87	0230	800	300		"	03-02-88	0130	2400	225	
"	11-01-88	1940	2400	300		IC 4329A	05-03-87	0020	1000	300	
"	30-11-88	2000	2000	600		"	15-06-87	1900	1500	225	x
NGC 985	19-09-90	0145	2400	300		"	31-07-87	1715	1000	300	x
IC 1816	18-11-86	2130	1200	300		"	03-02-88	0215	2400	225	
"	01-08-87	0240	1000	300	x	1405.2-30	07-08-90	1855	2400	300	
ESO 198-G24	13-08-90	0405	2400	300		IRAS 1509-211	05-03-87	0215	1000	300	
H 0307-730	05-12-88	2315	1200	300	x	"	31-07-87	1815	1000	300	x
Fairall 1116	23-11-86	2200	600	300		"	07-08-90	1800	2400	300	x
"	31-07-87	0350	1000	300		Fairall 182	07-08-90	2115	1200	300	
"	11-01-88	2205	2400	300		Fairall 51	29-07-87	2025	800	300	
NGC 1566	04-01-88	2105	2400	300		"	07-08-90	2030	2400	300	x
Arakelian 120	30-11-88	2105	2400	600		ESO 141-G55	16-06-87	0100	1000	225	
MCG -5-13-17	04-03-87	2020	1000	300	x	"	29-07-87	2045	1000	300	
"	04-01-88	2155	2400	300		NGC 6814	29-07-87	2110	1000	300	
"	02-02-88	2200	2400	225		NGC 6860	07-08-90	2150	2400	300	
3A 0557-383	04-03-87	2110	1000	300	x	Markarian 509	08-08-90	2250	2400	300	x
"	11-01-88	2345	2400	300		H 2106-099	29-07-87	2205	1000	300	
F-265	04-01-88	2300	2400	300		"	08-08-90	2345	2400	300	x
NGC 2992	04-01-88	2350	2400	300		NGC 7213	16-06-87	0315	1200	225	
MCG -5-23-16	12-01-88	0035	2400	300		"	07-08-90	2310	2400	300	x
"	02-02-88	2255	2400	225		NGC 7214	12-08-90	0055	2400	300	
NGC 3783	04-03-87	2225	800	300		ESO 344-G16	16-06-87	0240	1500	225	
"	15-06-87	1745	1000	225	x	NGC 7314	29-07-87	2335	1000	300	
"	05-01-88	0055	2400	300	x	MCG -2-58-22	22-11-86	1835	600	300	x
"	02-02-88	2350	2400	225		"	30-07-87	0015	1000	300	
						"	05-12-88	1905	2400	300	

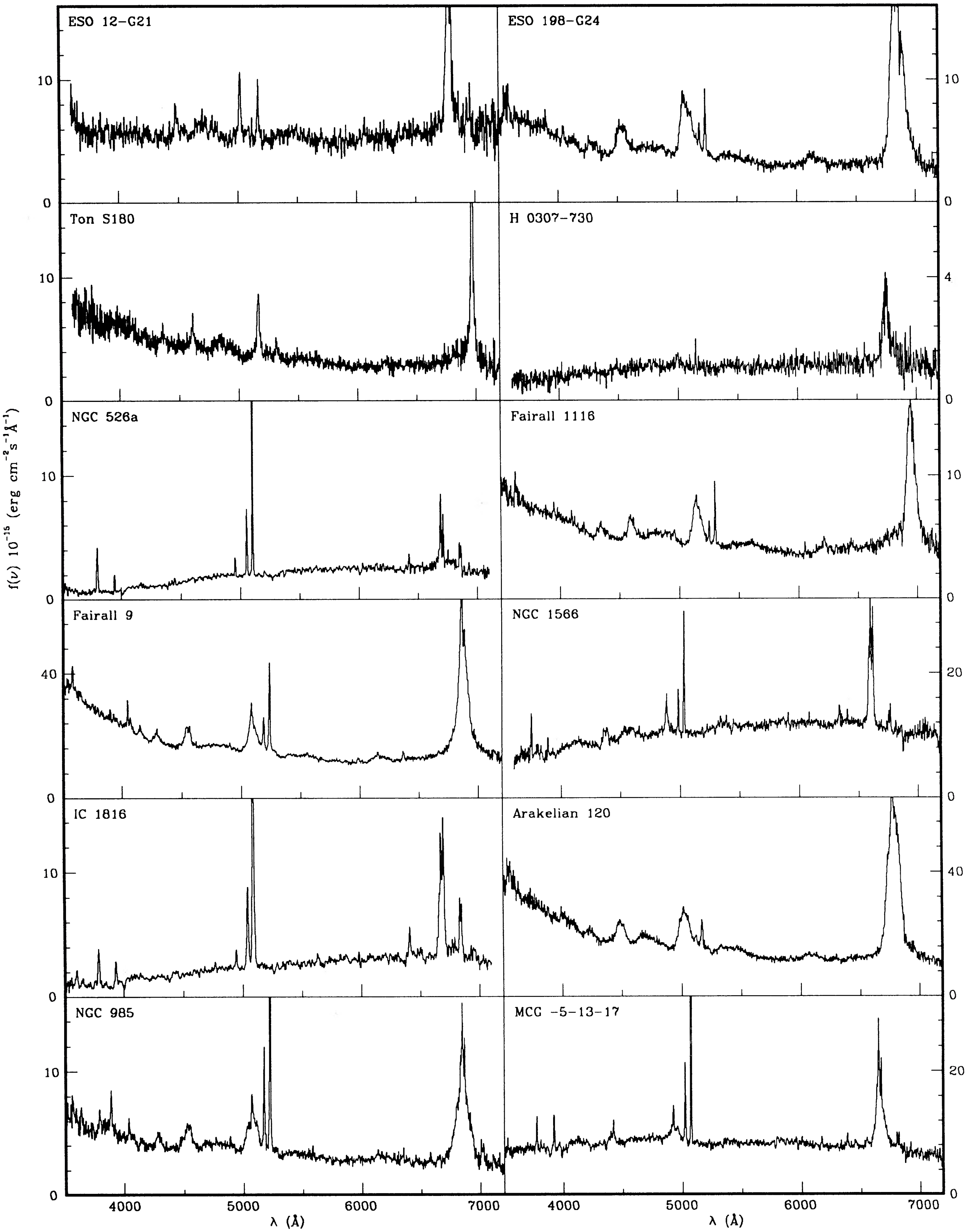

Figure 1. The co-added spectra for the 36 observed galaxies.

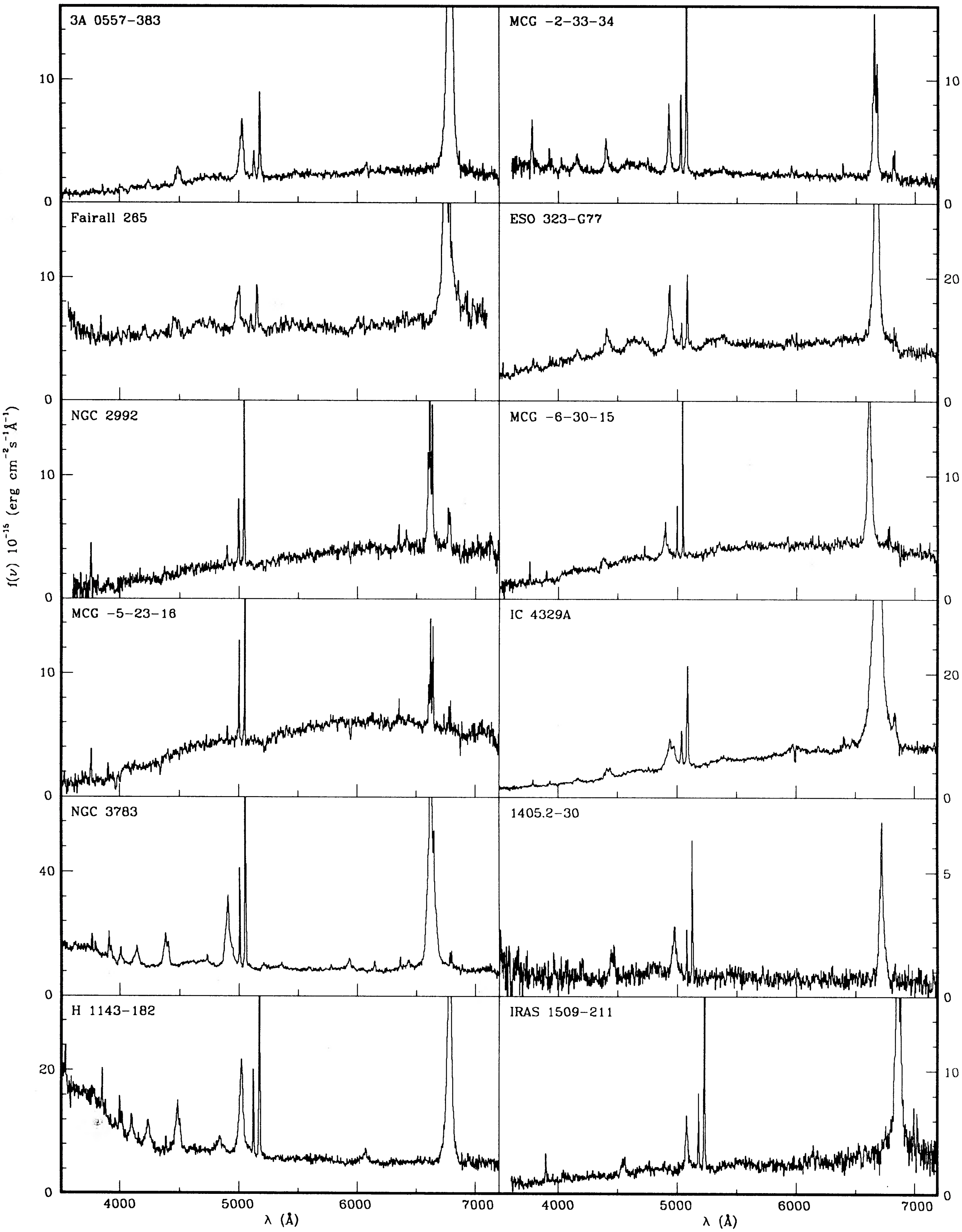

Figure 1 – *continued*

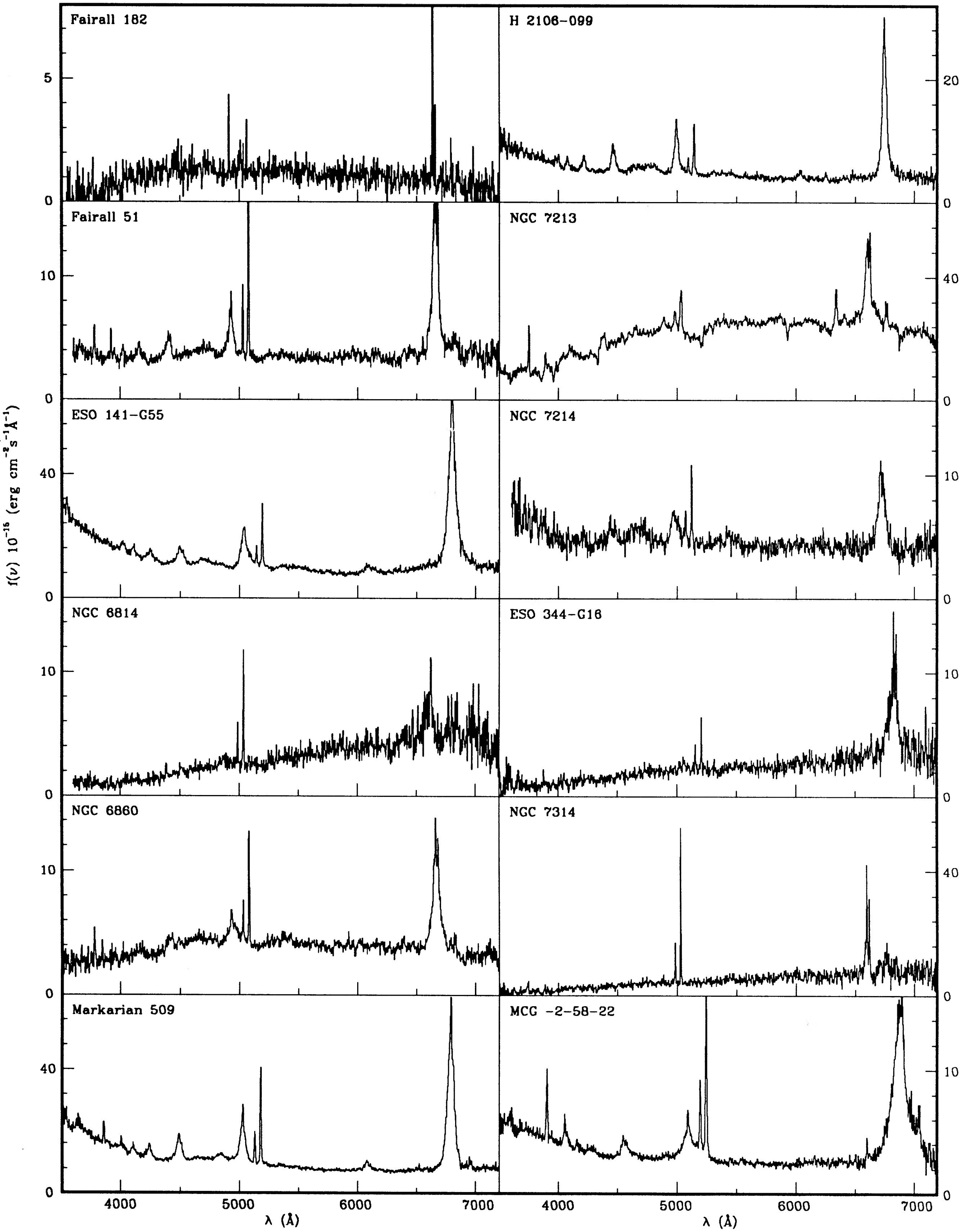

Figure 1 – *continued*

In column 7 of Table 3 the observed Seyfert galaxies have been classified according to an adaptation of the Lick scheme (Osterbrock 1977, 1981). To distinguish between subtypes the following criteria were used, $F(4861)/F(5007)$ being the Hβ to [O III] 5007-Å line ratio:

1.0: $F(4861)/F(5007) > 5.0$;
1.2: $2.0 < F(4861)/F(5007) < 5.0$;
1.5: $0.333 < F(4861)/F(5007) < 2.0$;
1.8: $F(4861)/F(5007) < 0.333$; broad component visible in Hα and Hβ;
1.9: broad component visible in Hα but ot in Hβ;
2.0: no broad component visible.

Some of the classes listed in Table 3 differ from those used by other investigators. Each such case will be discussed in the next section.

An average of the Hα and Hβ full widths at half-maximum is given in column 9 of Table 3. Table 4 lists the strengths of the hydrogen, helium and Fe II lines relative to Hβ, while the forbidden-line intensities relative to [O III] 5007 Å are given in Table 5. These have all been corrected for reddening in our Galaxy.

If more than one spectrum was available, the Hβ line was analysed for evidence of spectral changes by subtracting successive spectra from each other (see, e.g. Stirpe, De Bruyn & Van Groningen 1988). To do this the continuum was first removed and the spectra were normalized to a fixed [O III] 5007-Å flux value. It was assumed that for a specific object the [O III] flux remained constant throughout the period covered by this investigation, as the narrow-line region is expected to be several light-years in diameter (Peterson 1988). The last recorded continuum-subtracted Hβ spectra, as well as differences between successive spectra, have been plotted for 12 of the galaxies in Fig. 2.

4 NOTES ON INDIVIDUAL OBJECTS

In this section each of the objects is briefly described. The Seyfert types determined in this work are given in brackets after each galaxy's name.

ESO 12-G21 (1.5) was discovered by West, Grosbol and Sterken (Véron-Cetty & Véron 1989). Its spectrum, which has strong Fe II emission and broad lines of only moderate width in the ultraviolet (Clavel & Joly 1984), is found to exhibit these characteristics in the optical as well.

Ton S180 (1.2) is displayed by Véron-Cetty & Véron (1986), who do not, however, measure the spectral properties. Their spectrum looks similar to the one presented in this paper, with weak narrow lines, and broad lines with a relatively small width.

Table 3. The spectral properties of the galaxies.

Name	cz	F(Hβ)	L(Hβ)	F(5007)	L(5007)	Hβ/5007	Seyfert class	FWHM
	km s^{-1}	{ F: 10^{-13} erg cm^{-2}s^{-1}		L: erg s^{-1} (log) }				km s^{-1}
ESO 12-G21	9810	1.48	41.83	0.97	41.65	1.53	1.5	1000
Ton S180	18200	1.58	42.40	0.38	41.78	4.16	1.2	1000
NGC 526a	5680	0.22	40.53	2.27	41.54	0.10	1.9	-
Fairall 9	13770	9.66	42.94	4.23	42.58	2.28	1.2	3200
IC 1816	5000	0.50	40.78	4.54	41.73	0.11	2.0	-
NGC 985	12940	2.87	42.36	2.86	42.36	1.00	1.5	5500
ESO 198-G24	13640	5.73	42.71	0.64	41.76	8.96	1.0	6400
H 0307-730	8360	-	-	-	-	2.62	1.2	2900
Fairall 1116	17540	3.21	42.67	0.50	41.87	6.42	1.0	4300
NGC 1566	1460	1.66	40.23	1.82	40.27	0.91	1.5	1800
Arakelian 120	9790	17.63	42.91	2.29	42.02	7.70	1.0	5800
MCG -5-13-17	3750	2.00	41.13	3.88	41.42	0.52	1.5	4000
3A 0557-383	10100	2.01	41.99	0.98	41.68	2.05	1.2	2500
F 265	8690	1.43	41.71	0.60	41.34	2.40	1.2	2800
NGC 2992	2280	0.18	39.65	1.67	40.62	0.11	1.9	-
MCG -5-23-16	2540	0.13	39.60	2.27	40.85	0.06	2.0	-
NGC 3783	2800	13.18	41.69	11.50	41.63	1.15	1.5	2900
H 1143-182	9870	6.71	42.50	4.31	42.30	1.56	1.5	2400
MCG -2-33-34	4070	1.35	41.03	2.07	41.22	0.65	1.5	1500
ESO 323-G77	4540	5.26	41.72	2.16	41.33	2.44	1.2	2500
MCG -6-30-15	2270	1.30	40.51	1.00	40.39	1.30	1.5	2400
IC 4329A	4740	3.64	41.59	2.77	41.47	1.31	1.5	4800
1405.2-30	7100	0.81	41.29	0.63	41.18	1.28	1.5	2400
IRAS 1509-211	13350	1.59	42.13	2.24	42.28	0.71	1.5	2000
Fairall 182	3220	0.19	39.97	0.11	39.74	1.69	H II	-
Fairall 51	4140	2.69	41.34	1.87	41.19	1.44	1.5	2700
ESO 141-G55	11020	10.57	42.79	2.73	42.20	3.87	1.2	3600
NGC 6814	1660	0.66	39.94	1.20	40.20	0.55	1.5	-
NGC 6860	4360	1.43	41.11	0.95	40.94	1.50	1.5	3900
Markarian 509	10380	-	-	-	-	1.98	1.5	3100
H 2106-099	8100	4.43	42.14	1.28	41.60	3.46	1.2	2400
NGC 7213	1490	2.71	40.46	3.43	40.56	0.79	1.5:	3200
NGC 7214	6940	1.92	41.65	0.73	41.23	2.63	1.2	4500
ESO 344-G16	11840	0.34	41.36	0.37	41.39	0.92	1.5	2500
NGC 7314	1420	0.18	39.24	3.40	40.52	0.05	2.0	-
MCG -2-58-22	14210	3.04	42.47	2.19	42.33	1.39	1.5	5600

Table 4. Permitted line fluxes relative to Hβ, corrected for reddening in our Galaxy.

Name	HI 3889	HI 3970	HI 4102	HI 4340	FeII 4550	HeII 4686	HeI 5875	HI 6563
ESO 12-G21	-	-	-	0.65	2.08	-	0.26	7.16
Ton S180	-	-	0.40	0.40	1.02	-	-	3.63
NGC 526a	-	-	-	0.50	-	-	-	3.00
Fairall 9	0.06	0.09	0.17	0.38	0.45	-	0.32	5.03
IC 1816	-	-	-	-	-	-	-	3.64
NGC 985	-	0.08	0.15	0.52	0.47	0.04	0.16	3.45
ESO 198-G24	-	-	0.13	0.38	0.26	-	0.17	3.35
H 0307-730	-	-	-	0.44	-	-	-	10.16
Fairall 1116	-	0.04	0.15	0.32	0.37	-	0.27	3.33
NGC 1566	-	-	-	0.52	1.50	-	0.10	3.39
Arakelian 120	-	-	0.14	0.45	0.46	-	0.23	4.54
MCG -5-13-17	-	-	-	0.36	0.60	-	-	4.37
3A 0557-383	-	-	0.10	0.35	0.40	-	0.17	8.95
Fairall 265	-	-	0.48	0.51	0.61	-	-	3.54
NGC 2992	-	-	-	0.58	-	-	0.49	19.28
MCG -5-23-16	-	-	-	-	-	0.49	-	8.74
NGC 3783	0.06	0.11	0.24	0.45	0.37	0.05	0.14	3.62
H 1143-182	0.07	0.16	0.30	0.58	-	0.25	0.15	2.98
MCG -2-33-34	0.05	0.06	0.29	0.56	1.10	-	0.13	2.67
ESO 323-G77	0.03	-	0.18	0.44	1.01	-	0.17	5.01
MCG -6-30-15	-	-	0.10	0.26	0.80	-	0.10	5.24
IC 4329A	-	-	0.09	0.30	0.36	-	0.56	12.90
1405.2-30	-	-	0.17	0.73	0.45	-	-	3.62
IRAS 1509-211	-	-	-	0.38	0.71	-	0.46	10.29
Fairall 182	-	-	-	-	-	-	-	2.75
Fairall 51	0.05	0.10	0.27	0.51	0.70	-	0.18	3.47
ESO 141-G55	-	0.08	0.18	0.40	0.39	-	0.32	4.50
NGC 6814	-	-	-	0.31	-	-	-	6.35
NGC 6860	-	-	-	0.36	0.39	-	-	5.15
Markarian 509	-	0.09	0.23	0.52	-	0.17	0.17	4.06
H 2106-099	0.06	0.11	0.22	0.57	0.72	-	0.15	3.22
NGC 7213	-	-	-	-	-	-	-	7.75
NGC 7214	-	-	0.24	0.47	0.90	-	-	2.63
ESO 344-G16	-	-	-	-	-	-	-	16.51
NGC 7314	-	-	-	-	-	-	-	15.63
MCG -2-58-22	0.07	-	0.18	0.40	-	0.05	0.05	5.73

NGC 526a (1.9) is listed as a type 1 Seyfert by Dahari & De Robertis (1988), although these authors made use of intermediate classes. In its discovery paper (Griffiths *et al.* 1979) it was, however, stated that a broad component was only visible for Hα. Fig. 1 confirms this description. A spectrum from 1978 (Martin Ward, private communication) shows that, at that time, the Hα broad component was much stronger. A broad Hβ component is again not visible.

The low value of Hα-to-Hβ ratio (= 3.0) shows that the narrow-line region is essentially unreddened. The broad-line region, on the other hand, must be significantly obscured, as the broad Hα component in Ward's 1978 spectrum is at least 10 times stronger than Hβ. This would also explain why, considering that no changes were noted in Paper I, its 2.2-μm flux has been observed to vary by almost 1 mag (Glass, private communication).

Fairall 9 (1.0) was discovered in 1977 at a particularly bright phase, when the Hβ flux was almost 10 times as large as that of [O III] 5007 Å (Fairall 1977; Ward *et al.* 1978; Hawley & Phillips 1978). Between 1981 and 1984 the broad-line intensities faded to about 1/10 of the 1977 values (Wamsteker *et al.* 1985; Kollatschny & Fricke 1985). Wamsteker *et al.* identified a component with a velocity of +2280 km s^{-1} relative to the Hβ peak ('red shoulder') that faded faster than the other components during 1982. During 1984 November, although the broad lines had weakened further, the red shoulder and Fe II lines were more prominent (Kollatschny & Fricke 1985).

After 1984 the nucleus started brightening again, although the luminosity has so far remained well below the 1977 level (see Paper I). Stirpe, Van Groningen & De Bruyn (1989) found that between 1982 October and 1987 January the wings of the Hβ line had faded less than the line centre. Relatively little changed during 1987 and 1988, but the 'red-shoulder' appears to have brightened in 1987 June/July (see Fig. 2).

IC 1816 (2.0) is, according to Maia *et al.* (1987), a type 1 Seyfert, on the basis of a broad Hα component and the presence of forbidden lines due to highly ionized iron. The evidence for the latter is, however, unconvincing, as [Fe X] 6374 Å is more likely to be [O I] 6363 Å, and [Fe VII] 6076 Å is doubtful in view of the noise in the spectrum. The broadening of Hα could be due to blending by the nitrogen lines, as the forbidden lines of this galaxy are relatively broad.

Menzies, Coulson & Sargent (1989) also suspected the presence of broad lines, but, as their spectrum did not include Hα, this conclusion was based on an inspection of the weak Hβ line only.

NGC 985 (1.5) was found to be a Seyfert by de Vaucouleurs & de Vaucouleurs (1975) at a time when, it seems, the Hβ-to-[O III] ratio was larger. A comparison of photometric measurements given by de Vaucouleurs & de Vaucouleurs with the data in Paper I confirms that NGC 985 was then brighter.

ESO 198–G24 (1.0) is not listed in the major active galactic nucleus (AGN) catalogues (e.g. Véron-Cetty & Véron 1989; Hewitt & Burbidge 1991), although Ward *et al.* (1987), who give no spectral information other than its recession velocity, call it a Seyfert 1. Fig. 1 shows its exceptionally strong and broad Balmer lines with peaks blueshifted by 2000 km s^{-1} relative to the narrow lines. Large continuum variations were reported in Paper I.

H 0307–730 (1.2) was observed spectroscopically by Remillard *et al.* (1986). Although the spectrum in Fig. 1 is by comparison only of low quality, no major changes are visible.

Fairall 1116 (1.0) is a luminous Seyfert independently discovered by Fairall (1988), whose spectrum is included in the analysis presented in this paper, and Maza & Ruiz (1989). No major variations have been detected, although the central parts of the Hβ line seem to have faded slightly between 1986 November and 1987 July.

NGC 1566 (1.5) has exhibited strong variations in the past decade (Alloin *et al.* 1985; Baribaud *et al.* 1992). Baribaud *et al.* observed a sudden rise in the broad-line strength in the 2 months prior to 1987 November 24. The bright phase lasted until at least 1988 January 4, when the spectrum shown in Fig. 1 was recorded. The continuum was also relatively strong in 1987 November (Paper I), but it had faded again by 1988 February.

Future flare-like outbursts could provide the opportunity to probe the structure of the nucleus in detail. The data collected for the late 1987–early 1988 outburst are too widely spaced in time to conduct such an analysis.

Arakelian 120 (1.0) is a bright, strongly variable object (e.g. Peterson *et al.* 1983, 1985; Alloin, Boisson & Pelat

Table 5. Forbidden line fluxes relative to [O III] 5007 Å, corrected for reddening in our Galaxy only.

Name	Nev 3427	OII 3727	FeVII 3760	NeIII 3869	SII 4069	OIII 4363	OIII 4959	FeVII 5721	FeVII 6086	OI 6300	Fex 6374	NII 6548	NII 6584	SII 6717	SII 6731
NGC 526a	-	0.48	-	0.15	-	-	0.37	-	-	0.07	-	0.06	0.20	0.08	0.08
Fairall 9	0.22	0.08	0.06	0.23	-	0.12	0.29	0.07	0.10	-	0.07	-	0.20	-	-
IC 1816	-	0.24	-	0.16	-	-	0.39	-	-	0.07	-	-	0.45	0.12	0.12
NGC 985	-	0.18	-	0.07	-	-	0.38	-	-	0.05	-	-	0.11	0.09	0.09
ESO 198-G24	-	0.27	-	0.45	-	-	0.45	-	-	-	-	-	-	0.13	+
Fairall 1116	0.59	0.20	-	0.22	-	0.09	0.39	0.18	0.39	-	-	-	-	0.54	+
NGC 1566	-	0.42	-	0.16	-	0.16	0.40	-	-	0.23	0.10	0.12	0.66	0.12	0.20
Arakelian 120	-	0.24	-	0.23	-	-	0.28	-	-	-	-	-	-	0.48	+
MCG -5-13-17	-	0.14	0.02	0.17	0.03	0.07	0.38	-	0.04	0.10	0.05	-	0.15	0.04	0.04
3A 0557-383	-	0.08	-	-	-	-	0.35	-	-	-	-	-	-	0.12	+
Fairall 265	-	0.76	-	-	-	-	0.26	-	-	-	-	-	1.35	-	-
NGC 2992	-	0.24	-	-	-	-	0.35	-	-	0.15	0.21	0.26	0.72	0.22	0.26
MCG -5-23-16	0.10	0.15	-	0.08	-	0.07	0.38	-	-	0.07	-	0.15	0.43	0.08	0.07
NGC 3783	0.12	0.05	0.03	0.10	-	0.05	0.34	0.01	0.06	0.04	0.06	-	0.09	0.03	0.04
H 1143-182	0.15	0.15	0.03	0.13	-	0.04	0.32	-	-	-	-	-	-	0.07	+
MCG -2-33-34	-	0.23	-	0.07	-	-	0.31	-	-	0.04	-	-	0.30	0.10	0.11
ESO 323-G77	-	0.13	-	0.16	-	-	0.30	-	-	-	-	-	-	0.24	+
MCG -6-30-15	-	0.18	-	0.08	-	-	0.32	-	-	-	-	-	-	0.12	0.13
IC 4329A	-	0.04	-	0.04	-	-	0.36	-	0.09	0.12	-	-	-	0.12	0.21
IRAS 1509-211	-	0.14	-	0.06	-	0.05	0.33	-	-	-	-	-	0.32	0.18	0.18
Fairall 182	-	2.20	-	-	-	-	0.84	-	-	-	-	0.69	2.04	1.59	+
Fairall 51	-	0.19	-	0.14	-	0.04	0.33	-	-	-	-	-	0.31	0.16	+
ESO 141-G55	0.25	-	-	-	-	-	0.28	-	-	-	-	-	-	0.28	+
NGC 6814	-	0.12	-	-	-	-	0.36	-	-	-	-	-	-	-	-
NGC 6860	-	0.50	-	-	-	-	0.37	-	-	0.18	-	-	0.33	0.32	+
Markarian 509	-	0.20	-	0.10	-	-	0.27	-	-	0.06	-	-	-	0.11	0.08
H 2106-099	-	0.13	-	0.15	-	-	0.34	-	0.21	0.13	-	-	-	-	-
NGC 7213	-	0.62	-	0.23	0.30	-	0.59	-	-	0.83	0.37	-	0.63	0.27	0.31
NGC 7214	-	-	-	0.23	-	-	0.66	-	-	-	-	-	-	-	-
ESO 344-G16	-	0.24	-	-	-	-	0.35	-	-	-	-	-	-	-	-
NGC 7314	-	0.05	-	0.03	-	-	0.25	-	-	0.07	-	0.18	0.44	0.10	0.15
MCG -2-58-22	0.13	0.31	-	0.20	-	-	0.43	-	-	0.12	0.06	-	0.14	0.24	+

Notes. Objects with [O III] 4959, 5007 Å and no other forbidden lines have not been included in this table. + denotes that the [S II] 6716, 6731-Å doublet could not be resolved. The total flux is given in the previous column.

1988). Alloin *et al.* found that the changes in the line profile are largely due to variations in two components ('shoulders'), separated by 4000 km s^{-1}, lying symmetrically about the line centre. Stirpe (1990) reports a decrease in both shoulders in the 4 years prior to 1987 January. 2 years later (Fig. 3) the wings appear stronger, while a central narrow peak is no longer as clearly visible.

MCG-5-13-17 (1.5) was listed as a Seyfert 1 by de Grijp, Miley & Lub (1987). A spectrum by Maia *et al.* (1987) shows Hα weaker than observed here. Fig. 2 suggests that Hβ was brightest during 1988 January.

3A 0557−383 (1.2) is an inclined spiral with a Seyfert 1 nucleus (Fairall, McHardy & Pye 1982). In a spectrum displayed by Rafanelli (1985), Hβ appears slightly stronger than at other stages.

Fairall 265 (1.2) was identified as a possible Seyfert by Fairall (1980). In Fig. 1, broad lines are clearly visible.

NGC 2992 (1.9) has a broad Hα component that seems to have varied in the past. During 1977 June and 1979 January it was slightly stronger than the narrow component of the same line (Ward *et al.* 1980; Shuder 1980), at about the same level as measured in this work. A spectrum displayed by Véron *et al.* (1980), however, shows a much stronger broad component.

MCG-5-23-16 (2.0), discovered by Schnopper *et al.* (1978), is an X-ray source with lines due to highly ionized elements. Note that a broad component, invisible in the Balmer spectrum, has been detected in Paschen β (Blanco, Ward & Wright 1990).

NGC 3783 (1.5) has been known to have variable line profiles since Menzies & Feast (1983) compared their Hα spectrum with one measured by Pelat *et al.* (1981) 5 years earlier. Between 1986 May and 1987 January Stirpe *et al.* (1988) found large changes in the He II 4686-Å line. A comparison of their spectra with one of 1984 March (Evans 1988) shows that a 'red shoulder', shifted by about +2000 km s^{-1} relative to the line peak, has developed and a bump has appeared on the blue wing. The profile again looked similar to that observed by Pelat *et al.*

Winge, Pastoriza & Storchi-Bergmann (1990) found the ratio of Hβ to [O III] 4959 Å to have been low (2.4) on 1988 May 10 and to have risen to 5.1 a year later. The 'red

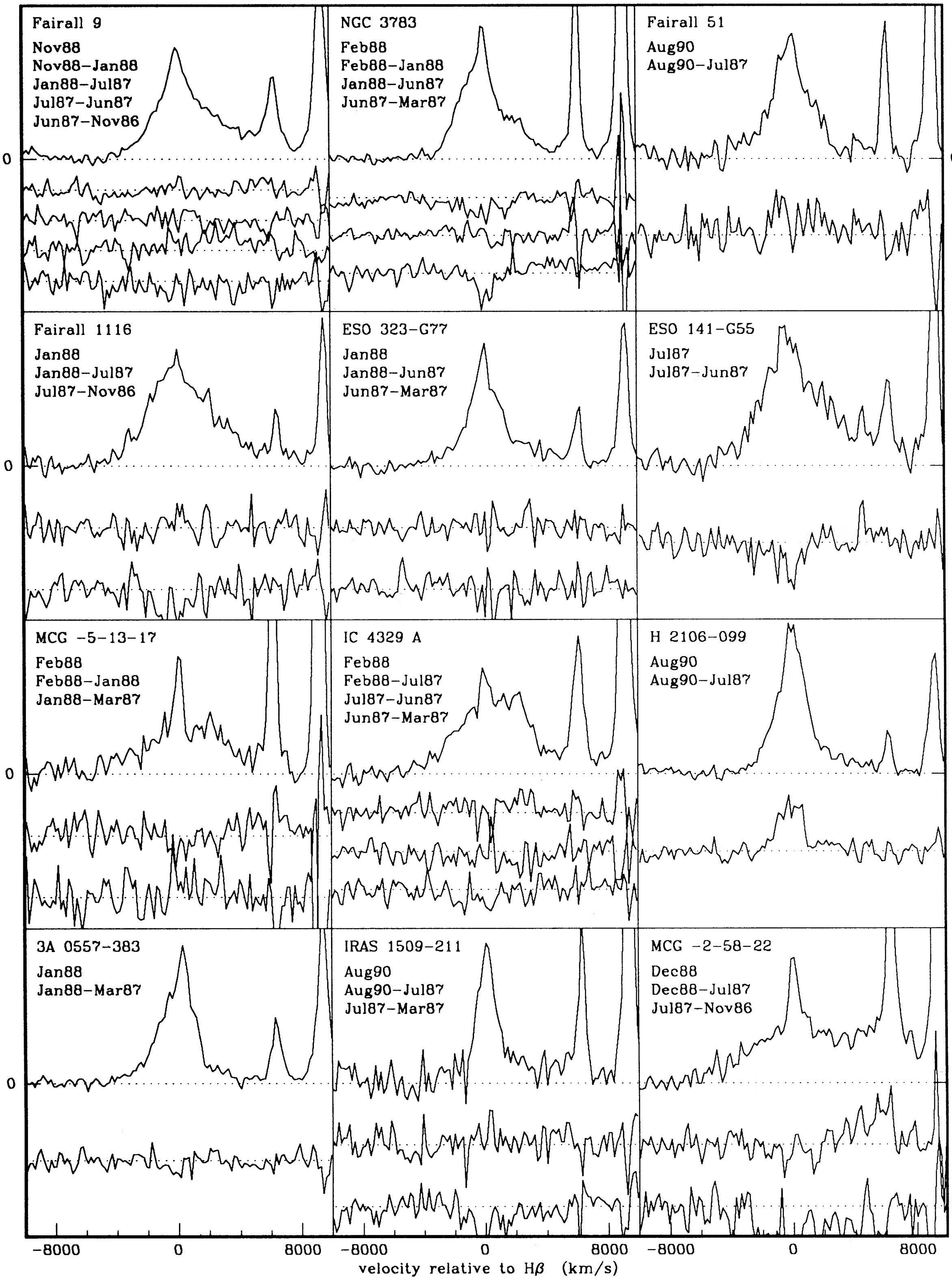

Figure 2. The Hβ line profiles of the 12 objects for which profile variations may be visible. The figure shows the most recent spectrum and the differences between successive spectra normalized to have equal [O III] 5007-Å fluxes.

shoulder' was a prominent feature during this period. The spectra displayed in Fig. 2 demonstrate the weakening of the central part of the broad-line component between 1987 March and 1988 February.

H1143−182 (1.5), discovered by Remillard *et al.* (1986), has weak Fe II emission, but a prominent He II 4686 line. Since the discovery its broad lines have become considerably stronger compared to [O III].

MCG-2-33-34 (1.5) is a now much-studied *IRAS* 'warm' source (Carter 1984; Osterbrock & De Robertis 1985; De Grijp *et al.* 1985; Maza & Ruiz 1989). Since its discovery, Hβ has gradually faded relative to the [O III] lines.

ESO 323−G77 (1.2) is a bright nearby Seyfert discovered by Fairall (1986). No spectral changes have been noted since.

MCG-6-30-15 (1.5), a Seyfert 1 discovered by Pineda *et al.* (1980), was observed on 1984 May 31 by Carter (1984), who measured an Hβ to [O III] 5007-Å ratio of 0.71. Within a week Morris & Ward (1988) also recorded a spectrum with the same telescope and instrument, finding the same ratio to be 1.57. Although Carter regards the Hβ flux as uncertain, an error by a factor of 2 in the relative flux seems improbable. Morris & Ward do not remark on this discrepancy. While similar slit sizes were used for both observations, Carter reported very bad seeing. This may mean that MCG-6-30-15 has a strong extended narrow-line region.

IC 4329A (1.5) is an inclined spiral that was once believed to be the nearest quasi-stellar object (Disney 1973; Wilson & Penston 1979), as the large Balmer decrement seemed to imply a nuclear extinction of $A_V \sim 5$. It is argued in Paper I that A_V is in fact much lower. The Wilson & Penston spectrum shows a 'red shoulder', strongest in Hβ, at a velocity of $\sim +2500$ km s^{-1}. This is the fourth object in the sample for which such a component has been identified. The 'red shoulder' may have brightened between 1987 July and 1988 February (see Fig. 2).

1405.2−30 (1.5) was described as a possible Seyfert 1 galaxy following its observation by Kinman (1983) during an objective prism survey. The spectrum in Fig. 1 shows that it is indeed a broad-line Seyfert.

It has subsequently been discovered that 1405.2-30 had been studied by Morris & Ward (1988), who called it 'Tol 20' in their paper (Morris, private communication). The designation 'Tol 20' originated with Kinman, who however changed it to 1405.2-30 because the name 'Tololo 20' was already being used for another galaxy (Phillips, private communication).

The galaxy was observed photometrically on 1988 February 22 with a 20-arcsec aperture, large enough to include most of the galaxy. The magnitude and colours measured were: $V=15.3$, $B-V=0.4$, $U-B=-0.7$, $V-R=0.5$, $V-I=0.9$. This implies a relatively low luminosity for a Seyfert 1 galaxy. The absolute magnitude and colours are in fact similar to those of the low-luminosity Seyfert 1 galaxy 0036−515 described by Winkler, Stirpe & Sekiguchi (1992).

IRAS 1509−211 (1.5) became of interest following the studies of objects with flat infrared spectra (Carter 1984; Osterbrock & De Robertis 1985; De Grijp *et al.* 1985). It was also observed by Maza & Ruiz (1989). No major spectral changes have been noted since its discovery, but a weakening of the broad-line component between 1987 March and July can be seen in Fig. 2.

Fairall 182 (H II) was observed by Fairall (1979), who described it as 'almost a Seyfert' with a 'very distinct bright nucleus' and 'strong emission lines'. Fe II emission lines were also suspected. Although it is not clear whether any other observations of Fairall 182 were ever made, this object was apparently included in a list of Seyfert 1 galaxies that was used by Martin *et al.* (1983) in a study of Seyfert galaxy polarization properties.

A photometric observation of this galaxy was made on 1987 August 26, using a 30-arcsec aperture, large enough to include most of the flux from the object. The luminosity derived from this measurement ($V=14.59$, $B-V=0.78$, $U-B=-0.05$, $V-R=0.56$, $V-I=1.10$, $M_V=-19.68$) is lower than expected for Seyfert galaxies. The spectrum displayed in Fig. 1 shows no sign of line broadening, with Hβ stronger than [O III] 4959 Å, and [N II] 6584 Å significantly weaker than Hα. Fairall 182 is therefore an H II galaxy.

Fairall 51 (1.5) was discovered by Fairall (1977), and has been observed frequently since (Hawley & Phillips 1978; Carter 1984; Rafanelli 1985; Morris & Ward 1988). Only minor changes have been noted. The broad lines were slightly brighter in 1990 August than 3 years earlier (Fig. 2).

ESO 141−G55 (1.2) was discovered by Ward *et al.* (1978). Observations by Rafanelli (1985) in 1982 October show strong broad lines with pronounced 'shoulders' about 10 Å on either side of the peak. In 1986 May the broad lines are much weaker and the 'red shoulder' is no longer visible (Stirpe 1990). Just over a year later there was also no evidence for the 'blue shoulder' (Fig. 2). Note that the broad lines faded during 1987 June/July.

NGC 6814 (1.5) has a nucleus that has been observed at a wide range of luminosities (Yee 1980; Morris & Ward 1988). Sekiguchi & Menzies (1989) describe the fading of the broad-line component between 1983 and 1985. During the period covered by this investigation the object was still in a very faint state.

NGC 6860 (1.5) was classified as a Seyfert 1 by Maia *et al.* (1987) and De Grijp *et al.* (1987).

Markarian 509 (1.5) is a luminous Seyfert 1 galaxy whose spectrum has been studied by many authors (Attwood, Baldwin & Carswell 1982; Phillips *et al.* 1983; Rafanelli 1985). The broad lines were very bright during 1984 June (Morris & Ward 1988). The profiles shown in Fig. 3 look similar to those of Attwood *et al.* and Rafanelli, although the narrow-line peak may be stronger.

H 2106−099 (1.2) was discovered by Remillard *et al.* (1986). Contrary to the claim of these authors, the He I 5876-Å line does not seem to be unusually strong. Fig. 2 shows that the broad lines strengthened considerably between 1987 July and 1990 August.

NGC 7213 (1.5:) has unusually strong [S II]4068-Å, [O III] 4363-Å and [O I] 6300-Å lines. Its peculiarities have been discussed in detail by Filippenko & Halpern (1984).

NGC 7214 (1.2) was found to be a Seyfert by Dahari (1985). No profile changes or other differences are evident, when comparing his spectrum and that presented in this paper, although Hβ appears to have strengthened in relation to the [O III] lines.

ESO 344-G16 (1.5) is classified as a Seyfert 1 by De Grijp *et al.* (1987), although no other details are given. Fig. 1 confirms the presence of a broad-line component. A photometric measurement was made on 1987 August 25, using a 30-arcsec aperture: $V=14.54$, $B-V=0.78$, $U-B=0.04$, $V-R=0.58$, $V-I=1.14$.

NGC 7314 (2.0) has the spectrum of a type 2 Seyfert. Stauffer (1982), however, stated that Hα has a weak broad component. Morris & Ward (1988) do not see this component, but point out that there is evidence of a hidden type 1 nucleus (X-rays, O I 8446 Å).

MCG-2-58-22 (1.5) is a highly variable object (see Paper

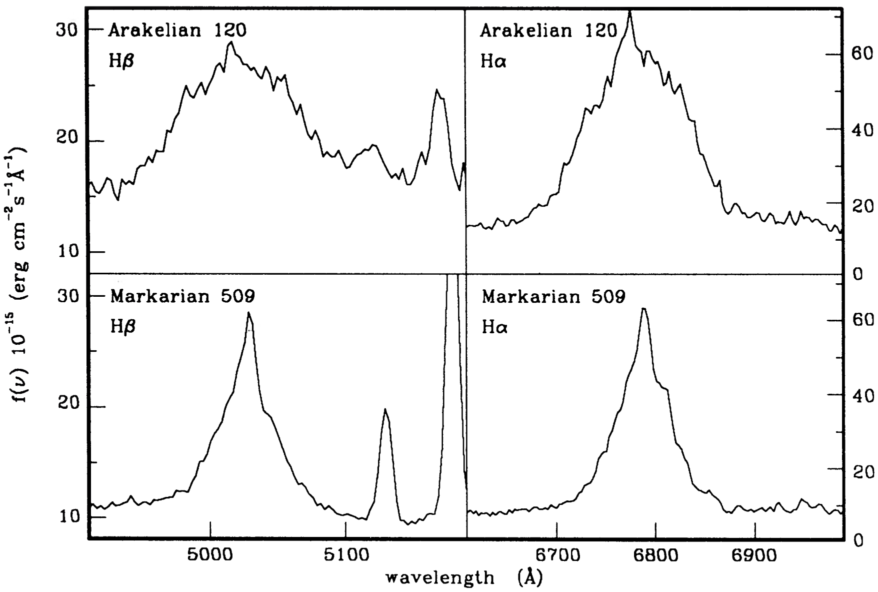

Figure 3. The Hα and Hβ lines of Arakelian 120 and Markarian 509.

I) with remarkably broad Balmer lines. In the discovery spectrum of Ward *et al.* (1978) the broad lines are considerably more luminous than measured at later times, and Hβ has a strong blue wing, possibly due to He II. In the 1978 September spectrum recorded by Durret & Bergeron (1988) the broad lines are much weaker, the blue wing has disappeared, and a narrow Hβ component is clearly visible. A year later two blue emission components had appeared in the Hβ line, with velocities of about -1000 and -5000 km s^{-1} relative to the Hβ narrow line (Osterbrock & Shuder 1982). A similar profile was observed in 1982 October (Rafanelli 1985). In 1984 June emission, probably due to He II was again present on the blue wing of Hβ (Morris & Ward 1988).

The development of the spectrum since late 1986 is shown in Fig. 2. The whole Hβ line faded relative to [O III] until mid-1987. After that, a red component ($v \sim +5000$ km s^{-1}) developed. In Fig. 1 the blue wing is no longer visible, although weak He II emission seems to be present.

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