Ultraviolet properties of early-type galaxies^{*}

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Abstract. — We analyse the UV properties of early-type galaxies from their UV spectra in the IUE library, including both normal and active nuclei. We co-added the spectra, and hence the objects into groups of similar spectral properties in the UV, also taking into account their properties in the visible/near-infrared ranges. Although, owing to the presence of a residual fixed pattern noise, IUE data cannot be improved by co-addition as expected for spectra containing only random noise, this procedure still provided spectra of higher signal/noise ratio than in previous studies, often based on individual spectra and therefrom derived colour indices. Thanks to the co-adding procedure, information on spectral features can now be assessed. The red stellar population groups exhibit a far-UV flux at different levels. The higher ones denote the presence of the UV turnup, which possibly exhibits absorption features, at least as detected through the IUE aperture. As to the blue stellar population groups and/or AGNs, we have carried out simple syntheses with UV star cluster templates and galaxy spectra in order to infer the properties such as burst ages and contamination by an active nucleus. It has been possible to derive information on the extinction law affecting some internally reddened galaxies; there are cases where the presence of the $\lambda 2200$ Å absorption feature suggests a reddening law similar to the Galactic one, and others without the $\lambda 2200$ Å feature, suggesting that it is rather an SMC type law which applies, then.

Key words: (ISM:) dust, extinction — galaxies: active — galaxies: elliptical and lenticular, cD — galaxies: general — galaxies: stellar content — ultraviolet: galaxies

1. Introduction

The International Ultraviolet Explorer (IUE) Satellite has been collecting fundamental data on a wide variety of astronomical objects since 1978. Recently we have used the IUE library to study the spectral properties of a large sample of integrated star cluster spectra with an unprecedented signal to noise (S/N) ratio by co-adding them into groups. The grouping procedure allowed us to analyse in detail the far-UV properties of star clusters and to provide reliable information on absorption features. The results of this analysis were presented in Bonatto et al. (1995, hereafter Paper I).

Regarding galaxies, several studies of IUE spectra by object class have already been carried out, e.g. the spectral atlases by Kinney et al. (1993) for star-forming galaxies, and by Rosa et al. (1984) for H II complexes.

In this paper we gather the spectra of the early-type galaxies stored in the IUE database and analyse the ensembles of normal and active early-type galaxies, in view

of better understanding their far-UV spectral properties. We also use, for the interpretation, single-aged UV templates of stellar populations, i.e. the star cluster spectral groups from Paper I, which help constrain the conclusions.

Some normal early-type galaxies (in this paper, ellipticals and S0's) are known to emit large amounts of energy in the far-UV, producing the so-called UV turnup (e.g. Bertola et al. 1980; Oke et al. 1981). However, the characteristics and origin of this emission are not yet fully understood. So far, studies of these objects have been performed from individual IUE spectra which usually have a rather low (S/N) ratio, or have been based on colour indices (Burstein et al. 1988; Longo et al. 1991). Bica & Alloin (1988) have used interpolated continuum distribution.

The analyses of IUE spectra of Active Galactic Nuclei (AGNs) in early-type galaxies have been mostly focused on variability, e.g. NGC 3516 (Wanders et al. 1993) and Mk 279 (Stirpe et al. 1994). Our goal here is to study time average properties by co-adding spectra of a given AGN, then classifying and co-adding the average spectra into groups of comparable spectral characteristics. So we work with the average activity state in which each AGN was observed.

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This paper is organised as follows: in Sect. 2 we present the IUE data on early-type galaxies. In Sect. 3 we group the objects according to spectral similarities from the UV to the visible/near-IR ranges. Equivalent width and continuum measurements are presented in Sect. 4. In Sect. 5 we discuss spectral groups as well as some interesting individual objects. Concluding remarks are provided in Sect. 6.

2. The data

Fig. 1. Groups for red stellar populations in early-type galaxies with different contributions from the UV turnup. Flux in F_λ units, normalised at λ_{2646} Å. Constants have been added to the spectra for clarity purposes, except for the bottom one

The spectra have been extracted from the IUE database as stored at the Instituto Astronômico e Geofísico of the Universidade de São Paulo (IAG-USP). We have selected the available SWP, LWP and LWR spectra of early-type galaxies obtained in the large aperture ($10'' \times 20''$) mode. In Table 1 we present the objects used in this study along with some relevant data. Only objects with a morphological type $T < 0$ have been used (de Vaucouleurs et al. 1991, hereafter RC3). We also included NGC 5253 which was classified as a peculiar early-type galaxy ($T = 10$) in the RC3 (see also Sérsic et al. 1972). We use as well in the discussion IUE spectra with high (S/N) ratio for some control galaxies, which are NGC 5236 (nuclear starburst in a spiral galaxy; Pastoriza 1975), NGC 1068 (Seyfert 2 in a spiral galaxy), NGC 4151 (Seyfert 1 in late-type spiral) and NGC 7213 (Seyfert 1/LINER in an early-type spiral). We have gath-

Fig. 2. Groups for AGN together with groups for blue stellar populations in early-type galaxies. Notice how the two groups of Seyfert 1s have similar emission lines while diverging in the continuum slope. Flux in F_λ units, normalised at λ_{2646} Å. Constants have been added to the spectra for clarity purposes, except for the bottom one

ered in Table 1 the following information on the early-type sample galaxies, by columns: (1) different identifications; (2) PGC number; (3) morphological type (T); (4) foreground absorption A_B ; (5) total blue magnitude B_T ; (6) M_B assuming $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$; (7) heliocentric radial velocity, and (8) complementary remarks. Absolute magnitudes M_B were calculated using Galactic Standard of Rest (V_G) velocities (RC3), while optical and HI heliocentric velocities (V_R) were considered for redshift corrections in the IUE spectra. The main sources (and references therein) were: RC3 (identifications, PGC number, T , V_R , A_B , B , V_G for M_B calculations); Sandage & Tammann (1981) for V_G in some groups of galaxies; Mazzarella & Balzano (1986) for data on Markarian galaxies; Véron & Véron (1991) and Hewitt & Burbidge (1993) for data on AGNs. Additional relevant references are given in Sect. 3. The A_B values were used to correct all spectra for the foreground (Galactic) reddening using Seaton's (1979) law and $A_B/E(B - V) = 4.0$. Thus, in the subsequent analyses all spectra are corrected for the *foreground reddening and redshift*.

Table 1. Early-type galaxies

Object	PGC #	T	A_B mag	B_T mag	M_B mag	V_R km s ⁻¹	Remarks
ESO 252-G18	17116	-2.0	0.10	15.94	-19.8	10172	Seyfert 1, Radio Galaxy
ESO 434-G40, MCG-05-23-0016	28144	*	0.49	13.54	-19.5	2482	Seyfert 2
IC 450, Mk 6, UGC 3547, ARP 121	19756	-0.5	0.36	14.48	-20.2	5440	Seyfert 2
IC 1065, UGC 9553, 3C 305	52924	-2.0	0.03	14.43	-21.7	12423	Radio Galaxy
IC 3370, ESO 322-G14, IRAS 100469-3903	40887	-5.0	0.35	11.59	-21.7	2930	in cluster
IC 4296, ESO 383-G39, MCG-06-30-0016	48040	-5.0	0.13	11.42	-22.2	3727	Radio Galaxy, in cluster
IC 4329A, ESO 445-G50, MCG-05-33-0021	49051	-0.7	0.15	13.67	-20.5	4762	Seyfert 1, strong dust lane
IC 5063, ESO 187-G23, IRAS 20481-5715	65600	-0.8	0.25	12.58	-21.0	3400	Seyfert 2
MCG+08-31-0041, ARP 102B, UGC 10814	60067	-5.0	0.07	14.94	-20.0	7172	Seyfert 1
M 32, NGC 221, UGC 452, Ark 12, ARP 168	2555	-6.0	0.33	8.72	-15.7	186	in Local group
M 49, NGC 4472, UGC 7629, ARP 134	41220	-5.0	0.00	9.33	-21.4	983	H II galaxy, in Virgo cluster
M 59, NGC 4621, UGC 7858, VCC 1903	42628	-5.0	0.07	10.53	-20.2	444	in Virgo cluster
M 60, NGC 4649, UGC 7898, in ARP 116	42831	-5.0	0.04	9.70	-21.0	1114	in Virgo cluster
M 84, NGC 4374, UGC 7494, VCC 763, 3C 272.1	40455	-5.0	0.13	10.01	-20.8	1098	in Virgo cluster
M 85, NGC 4382, UGC 7508, VCC 798	40515	-1.0	0.03	9.99	-20.7	754	in Virgo cluster
M 86, NGC 4406, UGC 7532, VCC 881	40653	-5.0	0.12	9.74	-21.1	-248	in Virgo cluster
M 87, NGC 4486, UGC 7654, ARP 152, 3C 274.0, Vir A	41361	-4.0	0.10	9.49	-21.3	1282	Strong LINER, Radio Galaxy, in Virgo cluster
M 89, NGC 4552, UGC 7760, VCC 1632	41968	-5.0	0.15	10.57	-20.3	397	in Virgo cluster
M 105, NGC 3379, UGC 5902	32256	-5.0	0.05	10.18	-20.3	889	
Mk 9, Haro 1, CGCG 286- 36	21400	-2.0	0.14	14.97	-21.1	11587	Seyfert 1
Mk 49=Mk 1318, Haro 8, UGC 7354	39628	-5.0	0.02	14.44	-17.3	1684	H II
Mk 198, MCG+08-22-0073	38613	-2.0	0.00	14.86	-20.0	7084	Seyfert 2
Mk 279, UGC 8823	49321	-2.0	0.00	14.43	-20.9	8778	Seyfert 1, in pair
Mk 290, QSO 1534+580	55551	-5.0	0.01	15.07	-20.3	8690	Seyfert 1
Mk 352, IRAS 0057+316	3575	-2.0	0.24	14.49	-19.6	4437	Seyfert 1
Mk 573, UM 363, UGC 1214	6367	-1.0	0.03	13.57	-20.7	5175	Seyfert 2, in pair
Mk 705, UGC 5025, Ark 202, VIIIZw 47	26753	-2.0	0.08	14.50	-20.9	8545	Seyfert 1
Mk 960, Haro 15, MCG-02-03-0019	2845	-2.0	0.09	13.90	-20.5	5359	H II galaxy, in system
Mk 1018, UM 393, UGC 1597	8029	-2.0	0.01	14.10	-21.9	12077	Seyfert 1
Mk 1506, UGC 3087, IIZw 14, IRAS 0435+0514, MCG+01-12-0009	15504	-2.0	0.61	14.20	-21.9	9528	Seyfert 1
NGC 185, UGC 396, IRAS 00362+4803	2329	-5.0	0.83	9.28	-15.7	-251	in Local group
NGC 205, UGC 426, IRAS 00376+4124	2429	-5.0	0.15	8.79	-15.5	-344	in Local group
NGC 244, MCG-03-03-0003, VV 728	2675	-1.7	0.02	13.00	-17.4	944	
NGC 404, UGC 718, IRAS 01066+3527	4126	-3.0	0.24	10.92	-14.3	-19	in Local group?
NGC 584, MCG-01-04-0060	5663	-5.0	0.14	11.21	-20.9	1864	
NGC 936, UGC 1929	9359	-1.0	0.05	10.98	-20.4	1400	
NGC 1023, UGC 2154, ARP 135	10123	-3.0	0.27	10.08	-19.7	601	
NGC 1052, MCG-01-07-0034, IRAS 02386-0828	10175	-5.0	0.06	11.35	-20.2	1474	Strong LINER
NGC 1106, UGC 2322, IRAS 02474+4127	10792	-1.0	0.32	12.92	-21.1	4205	Seyfert 2
NGC 1316, ESO 357-G22, ARP 154, For A	12651	-2.0	0.00	9.40	-22.1	1172	Radio Galaxy, in Fornax cluster
NGC 1326, ESO 357-G26, IRAS 03220-3638	12709	-1.0	0.00	11.39	-20.1	415	in Fornax cluster
NGC 1399, ESO 358-G45	13418	-5.0	0.00	10.44	-21.0	1483	in Fornax cluster
NGC 1404, ESO 358-G46	13433	-5.0	0.00	10.98	-20.5	1483	in Fornax cluster
NGC 1407, ESO 548-G67	13505	-5.0	0.17	10.71	-21.3	1762	
NGC 1510, ESO 250-G3, IRAS 04019-4332	14375	-2.3	0.00	13.45	-17.1	989	H II galaxy, in pair
NGC 1533, ESO 157-G3, IRAS 04088-5614	14582	-3.0	0.00	11.74	-18.0	668	in group
NGC 1553, ESO 157-G17, IRAS 04150-5554	14765	-2.0	0.00	10.26	-20.8	1239	in group
NGC 1705, ESO 158-G13, IRAS 04531-5326	16282	-3.0	0.19	12.58	-15.2	252	H II galaxy
NGC 1947, ESO 85-G87, IRAS 05264-6347	17296	-3.0	0.16	11.50	-19.6	1157	Strong dust lane
NGC 2110, MCG-01-15-0004	18030	-3.0	1.56	14.00	-20.0	2284	Seyfert 2
NGC 2217, ESO 489-G42, IRAS 06196-2712	18883	-1.0	0.15	11.35	-20.5	1609	
NGC 2768, UGC 4821	25915	-5.0	0.17	10.70	-20.7	1335	
NGC 2784, ESO 497-G23, AM 0910-235	25950	-2.0	0.79	10.46	-20.1	691	
NGC 2865, ESO 498-G1	26601	-5.0	0.29	12.18	-20.8	2611	
NGC 3115, MCG-01-26-0018	29265	-3.0	0.10	9.74	-20.1	670	
NGC 3125, ESO 435-G41, IRAS 10042-2941	29366	-5.0	0.27	13.11	-17.9	1080	H II galaxy, in cluster
NGC 3156, UGC 5503	29730	-2.0	0.04	12.91	-18.0	1118	
NGC 3311, ESO 501-G38	31478	-4.0	0.18	12.22	-21.5	3756	

Table Notes. (*) Lauberts (1982) classified this galaxy as S0.

3. Spectral groups

Galaxies exhibit a wide range of spectral properties, but those presenting similarities can be grouped, a procedure which allows one to study their average properties in more detail, from data with an improved (S/N) ratio. In order to obtain such data and to analyse the UV spectral lines it is necessary first to co-add the available IUE

spectra of each individual object, and subsequently to co-add into a spectral group the spectra of objects which show close similarities. In the present grouping procedure the ultimate criterion is the similarity of the UV spectra at the available (S/N) ratio. However, we also consider the spectral properties in the visible and near-IR ranges found in the literature, together with the classifications as **AGN**, H II galaxy, starburst or usual normal stellar

Table 1. continued

Object	PGC #	T	A _B mag	B _T mag	M _B mag	V _R km s ⁻¹	Remarks
NGC 3516, UGC 6153, IRAS 11033+7250	33623	-2.0	0.10	12.14	-20.7	2614	Seyfert 1
NGC 3894, UGC 6779	36889	-5.0	0.00	12.60	-20.5	3193	
NGC 3998, UGC 6946, MCG+09-20-0046	37642	-2.0	0.00	11.49	-19.3	1066	Strong LINER
NGC 4111, UGC 7103	38440	-1.0	0.00	11.60	-18.6	815	
NGC 4125, UGC 7118, IRAS 12055+6527	38524	-5.0	0.04	10.67	-20.6	1356	
NGC 4278, UGC 7386, IRAS 12175+2933	39764	-5.0	0.11	10.97	-18.8	628	Strong LINER, Radio Galaxy
NGC 4350, UGC 7473, VCC 685, Ark 362	40295	-2.0	0.03	11.93	-18.8	1158	in Virgo cluster
NGC 4385, M 52, UGC 7515, UM 499	40564	-1.0	0.03	12.90	-19.5	2271	H II galaxy
NGC 4494, UGC 7662	41441	-5.0	0.06	10.55	-20.7	1324	
NGC 4564, UGC 7773, VCC 1664	42051	-5.0	0.09	11.96	-18.8	1119	in Virgo cluster
NGC 4696, ESO 322-G91	43296	-4.0	0.50	10.85	-22.6	2958	in cluster
NGC 4697, MCG-01-33-0010	43276	-5.0	0.04	10.07	-21.0	1236	
NGC 4742, MCG-02-33-0032, IRAS 12490-1009	43594	-5.0	0.10	11.94	-19.3	1286	
NGC 4762, UGC 8016, VCC 2095	43733	-2.0	0.00	11.01	-19.9	971	in Virgo cluster
NGC 4853, UGC 8092, 2Zw 67	44481	-3.0	0.04	14.23	-20.8	7494	in Coma cluster
NGC 4874, UGC 8103	44628	-4.0	0.05	12.61	-22.3	7055	in Coma cluster
NGC 4889, UGC 8110	44715	-4.0	0.05	12.34	-22.4	6410	in Coma cluster
NGC 5044, MCG-03-34-0034	46115	-5.0	0.12	11.67	-21.2	2692	
NGC 5102, ESO 382-G50, IRAS 13191-3622	46674	-3.0	0.22	9.99	-17.9	715	in Centaurus group
NGC 5128, ESO 270-IG9, ARP 153, Cen A	46957	-2.0	0.24	7.30	-20.6	595	Strong dust lane, Radio Galaxy in Centaurus group
NGC 5253, ESO 445-G4, Haro 10, IRAS 13370-3123	48334	10.0	0.20	10.47	-17.4	547	in Centaurus group
NGC 5266, ESO 220-G33, IRAS 13399-4755	48593	-3.0	0.53	11.50	-22.1	3044	in group
NGC 5273, UGC 8675, MCG+06-30-0072	48521	-2.0	0.00	12.38	-18.3	1054	Seyfert 1
NGC 5283, M 270, UGC 8672	48425	-2.0	0.04	14.12	-19.3	3578	Seyfert 2
NGC 5670, ESO 272-G19	52161	-2.0	0.66	12.25	-21.3	2866	
NGC 5813, UGC 9655	53643	-5.0	0.16	11.42	-20.8	1924	
NGC 5846, UGC 9706	53932	-5.0	0.15	10.91	-21.0	1710	
NGC 6166, UGC 10409, VV 364	58265	-4.0	0.00	12.83	-22.6	8952	cD
NGC 6868, ESO 233-G39	64192	-5.0	0.15	11.49	-21.5	2836	in pair
NGC 7196, ESO 237-G36, IRAS 22026-5021	68020	-5.0	0.00	12.35	-20.6	2896	in group
NGC 7385, UGC 12207	69824	-5.0	0.16	13.12	-22.1	7699	Radio Galaxy
NGC 7465, M 313, UGC 12317, Ark 573	70295	-1.5	0.21	13.07	-19.3	1999	Seyfert 2

population types. In order to do this we have used the information from references quoted in Sect. 2 and the following ones, which were useful for classification according to stellar population and/or emitting gas characteristics: Heckman et al. (1980); Caldwell (1984); Dahari (1985); Filippenko & Sargent (1985); Bica & Alloin (1987a,b); Davies et al. (1987); Bettoni & Buson (1987); Gregg (1989); Bonatto et al. (1989); Terlevich et al. (1991); Bica et al. (1991); Buson et al. (1993); Osterbrock & Martel (1993); Goudfrooij et al. (1994); Gelderman & Whittle (1994); Storchi-Bergmann et al. (1995).

Three steps were taken to build up the final spectral groups: i) we averaged individual IUE spectra of a given object working separately in the short (SWP) and long (LWP and LWR) wavelength ranges. A few spectra were eliminated at this stage because they presented problems such as instrumental defects, discordant continuum distribution and/or spectral features; ii) we co-added spectra of different objects with comparable spectral properties — the ultimate criterion being the spectral similarity in the UV; and iii) the short and long wavelength domains were finally connected. The weight of each spectrum in the average was attributed according to the square of the (S/N) ratio.

In Tables ?? and ?? we present the resulting groups with the galaxies they are made of, along with the num-

ber of SWP and LWP/LWR spectra effectively used for each galaxy. The spectral group is named after a member which has spectra both in the SWP and LWP/LWR domains with a good (S/N) ratio. The projected IUE aperture in kpc is shown in Tables ?? and ?? for individual galaxies as well as its mean value for the group. We also recall in Tables ?? and ?? the spectral groups for the nuclear stellar population of early-type galaxies from the visible and near-IR ranges for which Bica (1988) carried out population syntheses: E1 to E4 are nuclear red stellar populations in a decreasing metallicity sequence; E5 is as strong-lined as E1 and E2, but appears to have a somewhat stronger intermediate age component; E7 exhibits an intermediate age burst of star formation and E8 had a burst ≈ 500 Myr ago. NGC 1533 and NGC 1316 were grouped with spirals in Bica (1988) following the morphological classifications of Sandage & Tammann (1981) as SB 0/SB a and S a peculiar respectively, resulting in the labels of nuclear stellar population spectral groups S1 (similar to E1) and S2 (similar to E2), respectively.

Groups of red stellar population in early-type galaxies are displayed in Fig. ?. Groups with active nuclei together with groups of blue stellar population in early-type galaxies are shown in Fig. ?. The IUE $\lambda 1790 \text{ \AA}$ réseau mark indicated in Fig. ? has been clipped out in the subsequent figures.

Table 2. Red stellar population spectral groups

Galaxy	SWP	LWP/R	slit (kpc×kpc)	Spectral Type
<i>With intermediate age burst</i>				
G_N221			$\langle 0.7 \times 1.5 \rangle$	
NGC 221	5	5	0.03×0.06	
NGC 2865	1	1	1.7×3.4	G-E 7
NGC 4111	2	2	0.5×1.1	
NGC 4382	1	1	0.7×1.4	G-E 7
NGC 4742	2	–	0.8×1.7	G-E 7
<i>UV weak</i>				
G_N1553			$\langle 1.2 \times 2.4 \rangle$	
NGC 244	–	1	0.6×1.2	
NGC 584	1	–	1.2×2.4	G-E 5
NGC 1316	1	1	0.8×1.5	G-S 2
NGC 1553	2	1	0.8×1.6	G-E 5
NGC 3311	1	–	2.4×4.9	
NGC 4494	1	–	0.9×1.7	
NGC 4696	2	–	1.9×3.8	
NGC 4697	2	1	0.8×1.6	G-E 5
NGC 4762	1	3	0.7×1.4	
NGC 5044	1	–	1.7×3.5	
NGC 5846	1	–	1.1×2.2	
NGC 6868	1	–	1.8×3.7	G-E 5
<i>UV weak</i>				
G_N3115			$\langle 0.9 \times 1.8 \rangle$	
IC 3370	1	–	1.9×3.8	
NGC 1023	–	1	0.4×0.9	
NGC 1533	–	1	0.4×0.9	G-S 1
NGC 2768	1	1	0.9×1.7	
NGC 3115	2	3	0.4×0.9	G-E 2
NGC 3379	2	2	0.6×1.2	G-E 2
NGC 4125	1	1	0.9×1.8	
NGC 4350	2	3	0.7×1.4	
NGC 4564	1	–	0.7×1.4	
NGC 5670	1	1	1.9×3.7	
NGC 5813	–	1	1.3×2.5	

Table Notes. Cols. 2 and 3 give the number of IUE spectra effectively used; Col. 4 gives the projected IUE aperture ($10'' \times 20''$) in kpc×kpc.

4. Measurements

In Paper I we defined a series of windows and regions in the UV which are useful for measuring equivalent widths (W) and continuum points. In Table 4 we present the Ws for the UV windows measured in the blue and red stellar population groups, as well as in some sample individual galaxies. The number and wavelength limits of the UV windows (as defined in Paper I), together with the main absorbers in each window, are given in the first three columns of Table 4, respectively.

Continuum points, normalised at $\lambda 2646 \text{ \AA}$, are provided in Table 5, where we have also included the Seyfert groups and their respective control galaxies. The quoted

Table 2. continued

Galaxy	SWP	LWP/R	slit (kpc×kpc)	Spectral Type
<i>Strong LINER</i>				
G_N3998			$\langle 3.1 \times 6.2 \rangle$	
NGC 3998	6	6	0.7×1.4	
NGC 4278	1	1	0.4×0.8	
IC 1065	1	1	8.1×16.1	
<i>Moderate UV turnup</i>				
G_N4472			$\langle 1.0 \times 2.0 \rangle$	
NGC 936	–	1	0.9×1.8	
NGC 1404	4	3	1.0×1.9	G-E 5
NGC 1407	4	–	1.1×2.3	
NGC 2217	–	3	1.0×2.1	
NGC 4374	2	1	0.7×1.4	G-E 5
NGC 4472	7	9	0.7×1.4	G-E 1
NGC 4621	1	2	0.7×1.4	G-E 1
NGC 7196	1	1	1.9×3.8	
<i>Strong LINERS, strong UV turnup</i>				
G_N4486			$\langle 0.8 \times 1.6 \rangle$	
NGC 1052	4	2	1.0×1.9	
NGC 4486	5	3	0.7×1.4	G-E 1
<i>Strong UV turnup</i>				
G_N4649			$\langle 1.4 \times 2.7 \rangle$	
IC 4296	–	1	2.4×4.8	G-E 5
NGC 1399	2	1	1.0×1.9	G-E 1
NGC 3894	–	1	2.1×4.2	
NGC 4406	1	1	0.7×1.4	G-E 1
NGC 4552	3	3	0.7×1.4	G-E 1
NGC 4649	2	2	0.7×1.4	G-E 1
NGC 5266	–	1	2.0×4.0	G-E 5
<i>Distant galaxies</i>				
G_N4853			$\langle 4.9 \times 9.8 \rangle$	
NGC 4853	2	2	4.9×9.7	
NGC 4874	1	–	4.6×9.2	
NGC 4889	1	–	4.2×8.3	
NGC 6166	4	–	5.8×11.6	
NGC 7385	1	–	5.0×10.0	

Table Notes. Cols. 2 and 3 give the number of IUE spectra effectively used; Col. 4 gives the projected IUE aperture ($10'' \times 20''$) in kpc×kpc.

uncertainties were estimated according to the (S/N) ratio in each region. Finally, for the Seyfert groups and control galaxies we measured the Ws and the widths (FWHM) of the most prominent emission lines. Results are given in Table 6.

We selected two strong absorption features in the LWP/R range ($\text{Mg II}_{\lambda\lambda 2796,2803}$ and $\text{Mg I}_{\lambda 2852}$) and plotted their Ws in Fig. ??, in order to investigate the basic properties of UV lines for galaxies and to compare them to the Ws for star clusters from Paper I. In the upper panel of Fig. ?? we show $W(\text{Mg II}_{\lambda\lambda 2796,2803})$ versus $W(\text{Mg I}_{\lambda 2852})$ for the blue stellar population groups and individual galaxies from Table 4. They occupy

Fig. 3. Equivalent widths of Mg I and Mg II for galaxy and/or groups (filled symbols). Upper panel: blue stellar population groups; lower panel: red stellar population groups. Equivalent widths of star cluster templates (open symbols) are also plotted for comparison (Paper I). Groups of strong LINERs, G_N3998 and G_N4486, have $W(\text{Mg II})$ diluted by emission

similar loci as the blue star clusters SWB I (age ≈ 10 Myr) to SWB IVA (age ≈ 200 Myr), and the template RH II which is an average of H II regions in M101, M33, LMC and SMC. The loci of the H II/amorphous galaxies NGC 1705, NGC 5253 and the group G_N1510 suggest that they are not pure H II regions, but contain a stellar population with an age dispersion. In the lower panel, the Ws for the red stellar population galaxy groups are compared to those of the globular cluster templates. For the globular clusters, the sequence from G 5 to G 2b (and 47 Tuc) increases in metallicity up to $[Z/Z_{\odot}] \approx -0.5$ (Paper I). As expected, the galaxy groups are close to the metal-rich globular clusters. They present larger Ws in Mg I, indicating higher metallicity, while their Ws are comparable in Mg II. This might be explained by a saturation effect in the galaxies, by the presence of some emission and/or by some interstellar absorption excess on the line of sight to the globular clusters. Notice that the groups G_N3998 and G_N4486, which are strong LINERs, have significantly smaller $W(\text{Mg II}_{\lambda 2796,2803})$ with respect to the other galaxy groups. This is certainly caused by the contribution of an $\text{Mg II}_{\lambda 2796,2803}$ line emission.

Table 3. AGN and blue stellar population spectral groups

Galaxy	SWP	LWP/R	slit (kpc×kpc)	Spectral Type
<i>Seyfert 1's – bluer ones</i>				
	G_Mk 279		$\langle 6.0 \times 11.9 \rangle$	
Mk 9	4	3	7.5×15.1	
Mk 279	25	13	5.7×11.4	
Mk 290	5	7	5.6×11.3	
Mk 352	2	1	2.9×5.8	
Mk 1018	6	1	7.9×15.7	
Mk 1506	40	19	6.2×12.4	
<i>Seyfert 1's – redder ones</i>				
	G_N3516		$\langle 3.9 \times 7.7 \rangle$	
ESO 252-G18	2	1	6.6×13.2	
MCG+08-31-0041	2	1	4.7×9.3	
Mk 705	1	–	5.6×11.1	
NGC 3516	35	23	1.7×3.4	
NGC 5273	2	1	0.7×1.4	
<i>Seyfert 2's</i>				
	G_Mk 573		$\langle 2.6 \times 5.1 \rangle$	
ESO 434-G40	1	–	1.6×3.2	
IC 450	2	3	3.5×7.1	
IC 5063	1	1	2.2×4.4	
Mk 198	1	1	4.6×9.2	
Mk 573	2	1	3.4×6.7	
NGC 1106	1	–	2.7×5.5	
NGC 2110	1	1	1.5×3.0	
NGC 5283	1	1	2.3×4.7	
NGC 7465	1	–	1.3×2.6	
<i>H II/amorphous galaxies</i>				
	G_N1510		$\langle 1.5 \times 3.0 \rangle$	
Mk 49	1	–	1.1×2.2	
Mk 960	1	1	3.5×7.0	
NGC 1510	2	1	0.6×1.3	
NGC 3125	2	1	0.7×1.4	
NGC 4385	1	1	1.5×3.0	
<i>Ageing bursts</i>				
	G_N5102		$\langle 0.3 \times 0.6 \rangle$	
NGC 185	–	1	0.03×0.06	
NGC 205	4	7	0.03×0.06	
NGC 3156	2	–	0.7×1.5	
NGC 5102	5	3	0.3×0.6	
	Individual objects		$\langle 0.8 \times 1.6 \rangle$	
IC 4329A	1	2	3.1×6.2	
NGC 404	3	2	0.2×0.4	
NGC 1326	1	1	0.9×1.9	
NGC 1705	10	14	0.4×1.8	
NGC 1947	1	–	0.7×1.5	
NGC 2784	1	1	0.4×0.9	
NGC 5128	13	10	0.3×0.6	
NGC 5253	6	6	0.3×0.6	
	Control galaxies		$\langle 0.7 \times 1.4 \rangle$	
NGC 1068	27	12	0.7×1.5	
NGC 4151	326	247	0.6×1.3	
NGC 5236	2	7	0.3×1.6	
NGC 7213	8	5	1.2×2.3	

Table Notes. Cols. 2 and 3 give the number of IUE spectra effectively used; Col. 4 gives the projected IUE aperture ($10'' \times 20''$) in kpc $\times$ kpc.

5. Discussion

5.1. Normal galaxies

The red stellar population groups, in particular the analyses of the UV turnup, are discussed in a separate paper (Bica et al. 1995). Here we simply point out that the UV turnup exhibits possible absorption features, at least as detected through the IUE aperture (Fig. ??). However, their reality still remains to be confirmed, owing to the presence of camera artifacts in long-exposure spectra (Crenshaw et al. 1990). On the other hand, we call

Table 4. Equivalent width measurements of absorption lines in red and blue stellar population groups

Table 5. Continuum measurements - C_λ/C_{2646}

attention to Fig. 8a of Paper I, in which we averaged all red stellar population star clusters in the IUE database, and the resulting very high (S/N) spectrum presents absorption features which can be recognised in the galaxy templates. Besides, the different redshift corrections tend to minimise the effects of camera artifacts. In what follows, we use some red groups as templates in some spectral syntheses.

5.1.1. Blue stellar populations

We compare in Fig. ?? the spectrum of the group G_N1510 (average of HII and amorphous galaxies) to that of NGC5253. As expected, the spectra are very similar. Emission lines are not characteristic features of the UV spectrum of HII galaxies. We also display in Fig. ?? the HII region template from Paper I (including SMC, LMC, M33 and M101 HII regions), the star cluster templates SWBI (age ≈ 10 Myr) and SWBII (age ≈ 25 Myr). The HII region template does not show either conspicuous emission lines (Paper I). Thus, the presence of strong emission lines in the UV spectra of galaxies, e.g. $\text{Mg II}_{\lambda\lambda 2796,2803}$, such as in those of Seyfert nuclei (Fig. ??) is not related to conventional star-formation, indicating the presence of activity. The different slopes of the HII region template and the HII galaxy spectra might be explained by a larger internal reddening in NGC5253 and G_N1510. If this is the case, the extinction law would necessarily be similar to that of the SMC because of the absence of the $\lambda 2200 \text{ \AA}$ absorption feature in the HII galaxies. Alternatively, the slope could also be changed by a combination of the HII template and other recent star formation templates, e.g. SWBII. Such galaxies would have been forming stars over the last ≈ 50 Myr.

We compare in Fig. ?? the spectrum of the group G_N5102 to those of the star cluster templates SWBIII (age ≈ 75 Myr), SWBIVA (age ≈ 200 Myr) and SWBV (age ≈ 1.2 Gyr). Two members of this galaxy group, NGC5102 and the M31 companion NGC205, were population-synthesized in the visible and near-IR ranges using a star cluster base in Bica (1988, NGC5102 therein referred to as template E8) and Bica et al. (1990), respectively. It was concluded that these galaxies had a strong burst of star formation at ages $t \approx 100 - 500$ Myr. In the UV (Fig. ??) we find that the cluster template SWBIVA (≈ 200 Myr) must be a major contributor to the G_N5102 group, and therefore we confirm the presence of a strong burst in the age range $100 - 500$ Myr.

5.1.2. Atypical spectra

Some spectra in the sample did not fit the group classifications. In the following we discuss their properties.

NGC1326. The spectrum of NGC1326 (Fig. ??) exhibits on its short wavelength range a slope and spectral

Fig. 4. The spectrum of the group G_N1510 is compared to that of NGC 5253 and to those of HII region and star cluster templates of different ages. Fluxes are in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes, except for the bottom one

features similar to those characterizing the nuclear starburst in NGC 5236, whereas at $\lambda > 2500 \text{ \AA}$ the flux increases as for a red stellar population (groups G_N1553 and G_N3115 in Fig. ??). We have undertaken a first level synthesis by adding these templates with different relative proportions and conclude that their proportions at the normalization wavelength $\lambda 2646 \text{ \AA}$ are 85% of a burst and 15% of the red population (see Fig. ??).

NGC 404. We compare in Fig. ?? the spectrum of the nearby dwarf galaxy NGC404 with that of the red stellar population group G_N221. The stellar population synthesis in the visible/near-IR of NGC404, which is a strong LINER as well (Schmidt et al. 1990), revealed a bulge population hardly attaining solar metallicity with evidence of young and intermediate age components. These young components are seen indeed as an excess flux in the UV as compared to the red group G_N221. They also have an impact on the relative intensities of strong absorption lines such as FeII, MgII and MgI (Fig. ??).

NGC 2784. The IUE spectrum of the galaxy NGC2784 has a rather low (S/N) ratio, allowing one only to infer a slope, intermediate between nuclear starburst spectra like NGC 5236 and the group G_N5102 (Figs. ?? and ??,

Table 6. Emission-line parameters

Galaxy	SiIII $_{\lambda 1400}$		CIV $_{\lambda 1549}$		HeII $_{\lambda 1640}$		CIII] $_{\lambda 1909}$		MgII $_{\lambda\lambda 2798,2803}$	
	W (Å)	FWHM (Å)	W (Å)	FWHM (Å)	W (Å)	FWHM (Å)	W (Å)	FWHM (Å)	W (Å)	FWHM (Å)
G_Mk279	13.9	27.2	78.4	28.5	7.3	24.5	22.4	32.6	34.8	44.1
G_N3516	8.2	21.3	93.1	36.7	10.2	18.0	41.1	39.3	31.4	45.3
G_Mk573	67.8	25.0	139.2	15.8	69.3	10.7	79.7	7.4	—	—
NGC4151	10.7	14.0	177.7	24.8	24.3	10.5	63.7	16.0	76.6	41.9
NGC7213	25.2	36.4	120.8	32.6	34.3	33.5	54.9	26.1	84.7	34.9
NGC1068	14.3	14.3	60.8	12.3	27.5	12.4	24.3	15.1	14.6	18.4

Table Notes. Equivalent width and FWHM of the most prominent emission lines present in the Seyfert groups; control galaxies are used for comparison. **Fig. 5.** The spectrum of the blue population group G_N5102 is compared to those of star cluster templates at different ages. Fluxes are in F_{λ} units, normalised at $\lambda 2646$ Å. Constants have been added to the spectra for clarity purposes, except for the bottom one **Fig. 6.** **a)** Spectrum of NGC 1326; **b)** synthesis; **c)** burst and **d)** red stellar-population components. For **a)** and **b)** fluxes are in F_{λ} units normalised at $\lambda 2646$ Å, while constants have been added to the spectra for clarity purposes. In **c)** and **d)**, actual F_{λ} proportions at $\lambda 2646$ Å are shown

respectively). Indeed, this S0 galaxy, also known as AM0910-235, may have developed a nuclear starburst since it shows signs of interaction with its dwarf companions (Arp & Madore 1987). Visible and near-IR spectra, as well as more exposed UV spectra, are necessary to further check this interesting possibility.

5.2. Seyfert galaxies

We obtained two groups of Seyfert 1 galaxies (Fig. ??): the spectrum of G_Mk279 is notably bluer than that of G_N3516. Otherwise, the equivalent widths and FWHM of the emission lines (Table 6) do not show systematic differences. In principle, three possibilities might account for the continuum difference between the two groups: i) a reddening difference; ii) that the galaxies in the two groups would be in a different average activity state; and

Fig. 7. No UV turnup is detected in the spectrum of the red stellar population group G_N221. The spectrum of the nearby dwarf galaxy NGC 404 shows evidence of young and intermediate age components. Fluxes are in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. A constant has been added to the upper spectrum for clarity purposes; the dashed line indicates the true zero level for NGC 404

iii) that the G_Mk279 group contains additionally a starburst component. We applied several tests in order to constrain these possibilities. If differential internal reddening is responsible for the effect, the reddening law should not have a strong $\lambda 2200 \text{ \AA}$ bump. This can be seen in Fig. ??, where the SMC extinction law (Prévot et al. 1984) with $E(B - V) = 0.10$, when applied to the G_N3516 spectrum, reproduces quite well that of G_Mk279. On the other hand, Seaton's (1979) law with $E(B - V) = 0.15$ already overestimates the $\lambda 2200 \text{ \AA}$ correction and, at the same time, underestimates the far-UV flux.

Assuming that the emission lines are comparable in the two groups of Seyfert 1 galaxies, we normalised the spectra to the $\text{Mg II}_{\lambda\lambda 2796,2803}$ line intensity and then obtained the difference spectrum G_Mk279 - G_N3516. In Fig. ?? we compare the difference spectrum to that of the typical nuclear starburst NGC 5236, and also to the power-law $F_\lambda \propto \lambda^{-1.8}$. The power-law fits well the continuum of the difference spectrum, and so does the starburst continuum. However, the starburst absorption lines are not conclusively present in the difference spectrum. On the other hand, both a power-law or a starburst continuum with such a steep slope would cause a considerable dilution of

Fig. 8. The redder Seyfert 1 group G_N3516 has been reddening corrected using **a)** a Galactic extinction law with $E(B - V) = 0.15$, and **b)** the SMC law with $E(B - V) = 0.10$. As compared to the bluer Seyfert 1 group G_Mk279, the Galactic law underestimates the far-UV flux and overestimates the $\lambda 2200 \text{ \AA}$ correction, whereas the SMC law produces a very similar spectrum. Fluxes are in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes, except for the bottom one. The strong C IV emission has been clipped for clarity

the equivalent widths of the emission lines of G_Mk279 with respect to those of G_N3516, which is not the case (Table 6).

Therefore, we conclude that internal reddening is a more likely cause of the continuum difference between the two Seyfert 1 groups. Within the scenario of the *Unified Model of AGNs* (Antonucci 1993), Seyfert 2 galaxies would be Seyfert 1s but with their BLR and central source hidden by a dusty torus. Within this frame, the active nuclei of galaxies in the group G_N3516 could be interpreted as seen at lines of sight which cross a larger amount of the dusty torus than in the case of the group G_Mk279. Would this be the case, our results from Fig. ?? imply that the extinction law in the dusty torus does not have a conspicuous $\lambda 2200 \text{ \AA}$ bump, and resembles that of the SMC.

We draw attention to the fact that in the group of the bluest Seyfert 1s (G_Mk279), the galaxy Mk 1506 exhibits a conspicuous absorption around $\lambda 2200 \text{ \AA}$ which denotes the presence of significant differential internal reddening with respect to the other Seyfert 1s in the group. Before

Fig. 9. The difference spectrum between the bluer (G_Mk279) and redder (G_N3516) Seyfert 1 groups is compared to a power-law continuum (thick solid line) and to the nuclear starburst NGC 5236. Fluxes are in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes, except for the bottom one

including Mk 1506 in the G_Mk279 group we corrected its spectrum for internal reddening effects. We considered the Galactic reddening law (Seaton 1979) which presents a bump at $\lambda \approx 2200 \text{ \AA}$, $R = 3.1$ and derived $E(B - V)_i = 0.20$ (Fig. ??).

In Fig. ?? we compare the SWP region of the Seyfert 2 group G_Mk573 with that of the Seyfert 2 prototype NGC 1068. It is worth noting that individual IUE spectra building up the G_Mk573 group are noisy and do not release much information. We decided that they were Seyfert 2 galaxies relying on their visible spectra counterpart (references in Sects. 2 and 3). The resulting UV spectrum of the group confirms the Seyfert 2 nature of its members because of its similarity to the spectrum of NGC 1068. The FWHM for the ensemble of the emission lines (Table 6) reinforces this conclusion. As to the equivalent widths, those in the group G_Mk573 are systematically larger than those of NGC 1068 (Table 6), suggesting a higher excitation and/or less contamination by the stellar continuum component in the former.

Fig. 10. The Seyfert 1 galaxy Mk 1506 has been reddening corrected using a Galactic law with $E(B - V)_i = 0.20$, which successfully cancels out the $\lambda 2200 \text{ \AA}$ absorption. Fluxes are in F_λ units normalised at $\lambda 2646 \text{ \AA}$. A constant was added to the upper spectrum for clarity purposes

5.3. Internally reddened galaxies

The galaxies NGC 5128, NGC 1947 and the Seyfert 1 IC 4329A are known to have their nuclei reddened by strong dust lanes, as derived from optical spectra and imaging (see RC3 and references therein cited).

5.3.1. NGC 5128

In the averaging procedure for NGC 5128 we have excluded the spectra SWP 1799 and LWR 1681 which appear to be related to a Galactic field star of spectral type A, and SWP 14164 and LWR 10749 which correspond to an H II region in the disk of NGC 5128 (Rosa et al. 1984). The remaining 13 SWP and 10 LWP/R spectra all look similar within the available (S/N) ratios, and their average is shown in Fig. ?. We also display in Fig. ? the SWP spectrum of NGC 1947 which, within the available (S/N) ratio, is compatible with that of NGC 5128. Compared to a typical red stellar population in early-type galaxies, e.g. the average of the groups G_N1553 and G_N3115 (Fig. ??), NGC 5128 presents a steeper slope at $\lambda < 2500 \text{ \AA}$ and significant differences in the intensity of the absorption features Mn II+ Fe II $_{\lambda 2577, 2586}$, Mg II $_{\lambda 2796, 2803}$, Mg I $_{\lambda 2852}$ and Fe I lines in the range $\lambda \lambda 3008 - 3059 \text{ \AA}$.

Fig. 11. The SWP region of the Seyfert 2 group G_Mk573 is compared to that of NGC 1068; emission lines in G_Mk573 have similar width and relative intensities as those of NGC 1068. Fluxes are in F_λ units, normalised at λ_{2646} Å. A constant was added to the upper spectrum for clarity purposes

In order to interpret the spectrum of NGC 5128, we assumed a disk population which can be represented by the average of the star cluster templates SWBI (age ≈ 10 Myr), SWBIV (age ≈ 200 Myr) and SWBV (LMC+SMC, age $\approx 1 - 2$ Gyr), and a bulge population which can be represented by the average of the galaxy groups G_N1553 and G_N3115. The relative proportions of disk and bulge components at λ_{2646} Å were found to be respectively, 0.9 and 0.1, a mixture which reproduces also reasonably well the absorption lines in NGC 5128 (Fig. ??). The resulting continuum (Σ in Fig. ??) requires some additional reddening in order to reproduce that of NGC 5128. Galactic and LMC reddening laws (Seaton 1979; Fitzpatrick 1986) are not suitable in this case, as they would produce too strong an absorption at λ_{2200} Å. On the other hand, the SMC law (Prévot et al. 1984) with $E(B - V) = 0.30$ (assuming $R = 3.1$) provides a good fit. This is another case of an external galaxy other than the Magellanic Clouds where the properties of the reddening law in the UV can be derived. Recently, Kinney et al. (1994) found that the λ_{2200} Å bump of the reddening law is not present in another galaxy (NGC 7552). The large proportion of the disk component relative to that of the bulge suggests that the nuclear regions of NGC 5128 are not contributing much to the integrated

Fig. 12. Internally reddened galaxies NGC 5128 and NGC 1947 compared to the red stellar population group G_N1553. Flux in F_λ units, normalised at λ_{2646} Å. Constants have been added to the spectra for clarity purposes, except for the bottom one; the true zero-levels for the upper spectra are shown as dashed lines

spectrum observed through the IUE aperture. The optical depth through the dust lane appears to be so large for the nucleus in the far-UV that only templates of the external shells in the bulge and of the disk would be relevant. The pronounced depth and narrow width of the $\text{Mn II}_{\lambda 2577}$ and/or $\text{Fe II}_{\lambda 2586}$, and also of the $\text{Mg II}_{\lambda \lambda 2796, 2803}$ features suggest that some interstellar contribution occurs. This interstellar component might have arisen either in the disk of NGC 5128 or in our Galaxy, because of the low radial velocity and low Galactic latitude of NGC 5128.

5.3.2. IC 4329A

The Seyfert 1 galaxy IC 4329A has a very reddened visible spectrum which becomes comparable to that of the almost face-on galaxy NGC 3783 after an internal reddening correction with $E(B - V)_i = 0.79$ has been applied (Bica & Alloin 1986). We show in the lower panel of Fig. ?? the IUE spectrum of IC 4329A (foreground reddening corrected, Sect. 2) where a conspicuous absorption around λ_{2200} Å indicates that the reddening law associated to the disk of this galaxy has a UV bump. Here we simply consider and apply the same excess $E(B - V)_i$ as for the visible and the Galactic reddening law (Seaton 1979): in the

Fig. 13. Synthesis of NGC 5128. Components are: 10% of a red stellar population and 90% of a disk population. The resulting spectrum was reddened using the SMC law with $E(B - V) = 0.30$. Flux in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes. In **a)** and **b)** actual F_λ proportions at $\lambda 2646 \text{ \AA}$ are shown

upper panel of Fig. ??, we compare the resulting spectrum to that of our control Seyfert 1 in the UV (NGC 4151). Indeed the $\lambda 2200 \text{ \AA}$ absorption is basically cancelled out. However, no prominent emission lines are detected in the corrected spectrum of IC 4329A. In the SWP region the noise level is large indeed, but still, even the strong emission line of C IV usual in AGNs does not show up. In the LWP/R region, the $\text{Mg II}_{\lambda\lambda 2796,2803}$ line emission is not detected either in IC 4329A. We conclude that the optical depth is so large for the AGN in the UV that its emission lines and continuum are hardly detectable.

5.4. Strong LINERs

The groups G_N3998 (formed by NGC 3998 and NGC 4278) and G_N4486 (NGC 4486 = M 87 and NGC 1052), host well-known and strong LINERs (see references in Sects. 2 and 3). The equivalent width analysis (Sect. 4) has shown that $\text{Mg II}_{\lambda\lambda 2796,2803}$ in emission is probably causing the decrease of the absorption intensity in the corresponding window. The stellar population in G_N4486 is very similar to that of the group G_N4649 (Fig. ??) which has a strong UV turnover. The group G_N3998 has a red stellar population with far-

Fig. 14. The Seyfert 1 galaxy IC 4329A has been reddening corrected using the Galactic law with $E(B - V) = 0.79$. The resulting spectrum is compared to that of NGC 4151; a roughly similar slope is found. Flux in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes, except for the bottom one

UV flux intermediate between the groups G_N4472 and G_N3115 (Fig. ??). It seems however to be disturbed by emissions such as Mg II , C IV and C III]. We investigate in Figs. ?? and ?? the possibility of a mini-Seyfert nucleus being present in both groups. Indeed, a contribution like NGC 7213 (a Seyfert 1/LINER galaxy nested in the bulge of an Sa galaxy) amounting to 20% of the flux at $\lambda 2646 \text{ \AA}$, when added to the spectrum of the group G_N4472, reproduces well the overall spectrum of G_N3998 (Fig. ??). A similar mixture can be performed for the G_N4486 group with an even smaller contribution from NGC 7213 added to the group G_N4649 (Fig. ??). In both the G_N3998 and G_N4649 groups, the presence of the Seyfert nucleus does not account for the UV turnover. In the case of G_N4486, this component cannot contribute more than 10% at $\lambda 2646 \text{ \AA}$.

6. Concluding remarks

We have gathered the UV spectra of the early-type galaxies (ellipticals and S0's) stored in the IUE database. We grouped the objects showing similar spectral characteristics from the UV to the visible/near-IR ranges. This procedure provided average spectra with improved (S/N) ratio,

Fig. 15. The spectrum of the strong LINER group G_N3998 can be reproduced by combining those of the Seyfert 1/LINER NGC7213 and the galaxy group G_N4472; proportions are, respectively, 20% and 80% of the flux at $\lambda 2646 \text{ \AA}$. Flux in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes, except for the bottom one

Fig. 16. The spectrum of the strong LINER group G_N4486 can be reproduced by combining those of the Seyfert 1/LINER NGC7213 and the galaxy group G_N4649; proportions are, respectively, 10% and 90% of the flux at $\lambda 2646 \text{ \AA}$. Flux in F_λ units, normalised at $\lambda 2646 \text{ \AA}$. Constants have been added to the spectra for clarity purposes, except for the bottom one

giving access to more reliable information about spectral features. The main results of this work are the following:

i) We obtained several spectral groups characterised by blue and red stellar populations, as well as others containing **AGN**;

ii) the UV turnup possibly presents absorption features, at least as detected through the IUE aperture, although camera artifacts may still be affecting this region;

iii) using star cluster templates of different ages, it was possible to infer the age distribution in the galaxy spectra dominated by blue stellar populations;

iv) two distinct Seyfert 1 galaxy groups were obtained: one (G_Mk279) is considerably bluer than the other (G_N3516); this difference in continuum slope can be fully accounted for by internal reddening only if we assume an SMC-like extinction law, i.e. without the $\lambda 2200 \text{ \AA}$ bump;

v) the galaxies classified as Seyfert 2 in the visible/near-IR ranges form the group G_Mk573. Their combined UV spectrum turns out to be similar to the spectrum of the Seyfert 2 prototype NGC1068, thus confirming the group members as Seyfert 2's in this wavelength range as well;

vi) we carried out a simple population synthesis of the spectrum of the reddened galaxy NGC5128. A good re-

presentation was found by using a combination of typical disk (age $\approx 10 - 2000 \text{ Myr}$) and bulge populations, which are reddened by the strong dust lane in this galaxy; the best result was obtained for an internal reddening correction using the SMC extinction law and $E(B - V)_i = 0.30$. The nuclear regions, in this case, do not contribute significantly to the UV spectrum;

vii) we investigated the possibility of a mini-Seyfert nucleus being present in the groups containing LINERs: for G_N3998 we found that a combination of 20% flux contribution at $\lambda 2646 \text{ \AA}$ from the spectrum of the Seyfert 1/LINER galaxy NGC7213 and 80% from the UV turnup group G_N4472, reproduces well the overall spectrum of the group; for G_N4486, we found that a good representation requires a 10% flux contribution from NGC7213 and 90% from G_N4649. In both groups the UV turnup is not caused by the mini-Seyfert far-UV continuum.

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