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Optical spectroscopy for a sample of southern binary galaxies⋆,⋆⋆

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ABSTRACT

Aims. This work is part of a joint observational program aiming to get photometric and spectroscopic information on southern pairs of galaxies. We present optical long-slit spectroscopic data on 80 probable components of pairs, 61 of them collected with a spectral resolution of 3.4 Å, and 19 with 12 Å. Nevertheless, our analysis takes into account 53 components of pairs with better spectral resolution, as 8 of these target galaxies actually belong to optical pairs. For the sample with better resolution, the covered wavelength range is $5724 \leq \lambda \leq 7036$ Å. The spectroscopic and photometric information is gathered for an analysis relating galaxy morphologies to their spectra.

Methods. We use H_α + $[N_{II}]$ and H_α equivalent widths as star formation tracers for the central region of our sample galaxies, and we classify the spectra according to the emission lines' relative strength by looking at their behavior.

Results. Some of our sample galaxies exhibit high central star formation, most of them belonging to close pairs. However, not all galaxies' components of close pairs show this behavior. This may be a clue that besides interaction, other agents can stimulate central emission in binary galaxies. We suggest an enhancement in the number of galaxies with peculiar spectra (probably Seyferts) in our binary sample, when compared to isolated galaxies. Our data indicates that the morphological types of interacting galaxies are related to their spectral characteristics, as almost all early-type galaxies of our sample do not exhibit central optical emission. We note that the star formation activity is most likely to take place in both pairs' components, with a slightly higher mean strength for the less bright component of the pair. It is interesting to point out that most spirals exhibiting a strong HII emission line spectra present either a bar or a peculiarity, but on a general basis we do not find an enhancement of star formation in our interaction sample.

Key words. galaxies: interactions

1. Introduction

There is much evidence that galaxy interactions are an important factor in enhancing energetic activities in the inner regions of individual galaxies. A broad review by Barnes & Hernquist (1992) suggests that tidal interactions and mergers could supply the gas fuel necessary either to trigger a starburst or to generate an active galactic nucleus (AGN) in galaxies. Other authors, such as Condon et al. (1982), and Smith & Kassim (1993), established the relationship between interactions and the enhancement emission in radio wavelengths; Joseph et al. (1984), Lonsdale et al. (1984), and Bushouse et al. (1988) the enhancement in the infrared emission; Keel et al. (1985), Kennicutt (1990), Sekiguchi & Wolstencroft (1992, 1993), and Donzelli & Pastoriza (1997) the enhancement in optical emission line; and de Souza et al. (1997) the enhancement in the blue continuum of interacting objects. While some authors reported an excess of Seyfert-type activity among interacting galaxies (Keel et al. 1985; Dahari 1985), others (Sekiguchi & Wolstencroft 1992, 1993; Donzelli & Pastoriza 1997) suggested that star formation is the dominant energy source of their activities.

However, not all binaries clearly exhibit this behavior. Bergvall & Johansson (1995) compared the broadband distribution of a sample of interacting galaxies with a sample of elliptical galaxies and did not find any sign of induced enhanced star formation in the central region of these galaxies. For these authors, it is unlikely that the effect of dust and the counteracting effect of star formation might make an observed distribution exactly like that of an old stellar population. Bergvall et al. (2003) also did not find evidence for a significant enhancement in star formation among interacting/merging galaxies, as compared to non-interacting galaxies, although they reported a moderate increase in the center region of interacting galaxies. Forbes et al. (1994) pointed out that the inner regions of a galaxy can be more sensitive to interactions than global measurements indicate. These authors found a slight trend for interacting galaxies to show bluer nuclear color than galaxies that are not in interaction. Nevertheless, Reduzzi & Rampazzo (1996) suggested that even a moderate interaction might be able to keep the gas within the nuclear region and enhance both star formation and nuclear activity in binary galaxies.

With the goal of studying details in galaxies belonging to pairs, we began a study of galaxies selected from the list of southern binary galaxies in Soares et al. (1995). The isolation criteria adopted by Soares et al. (1995) is based on local density enhancement; thus, it includes a larger fraction of wide pairs, but at the cost of a large contamination by false pairs. Soares et al. (1995) suggested that 20−30% of their listed pairs are optical. One aim of this work was to get homogeneous radial velocity measurements for their list of probable pairs, mainly for objects without radial velocities available at the beginning of

⋆ Based on data collected at the Observatório do Pico dos Dias, operated by Laboratório Nacional de Astrofisica, MCT, Brazil.
⋆⋆ Full Fig. 3 is only available in electronic form
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this project. Another goal was to check for a central star formation enhancement in our sample of probable pairs. We used the equivalent widths (*EW*) of H_α + [N_{II}] and H_α emission lines as star formation tracers. These emissions are usually associated with a measurement of the global photoionization rate provided by massive stars (>10 solar mass) that are related to recent star formation.

The list of probable pairs selected for this study covers a broad range of angular separation and different stages of interaction. For the majority of these pairs, we obtained photometric data as well (Couto da Silva & de Souza 2006). For all but two galaxies belonging to this sample, the morphological classification was obtained in a very accurate way in our photometric work, taking into account the inner structure of galaxies. This paper is organized as follows: Sect. 2 presents data acquisition; Sect. 3, radial velocities; Sect. 4, special spectra ; Sect. 5, central optical emission; Sect. 6, a discussion of our results; and Sect. 7, a summary of our main conclusions.

2. Data acquisition

The optical long-slit spectroscopic data was collected at the 1.6 m telescope located at the Observatório do Pico dos Dias, operated by the Laboratório Nacional de Astrofísica (LNA-Brazil), using a Boller & Chivens spectrograph mounted on Cassegrain focus and CCD detectors. Data was observed in two different runs. In the first run (data 1), we used a CCD detector with 268×1152 pixels of 22.5 μm; however, the data was stored in a format of 100×1152 pixels. The galaxies were observed using a 300 μm slit, a grating with 300 l/mm in first order. A focus conversion changed the telescope focus ratio from $f_{10.0}$ to $f_{13.5}$. The corresponding linear dispersion was settled in 179 Å/mm, the spectral resolution, $\Delta = 12$ Å, and the wavelength range covered was 4181 Å $\leq \lambda \leq$ 8818 Å, centered on 6500 Å. This range includes H_α, H_β, O_{III}, N_{II}, and S_{II} lines, appropriate to the analysis of emission spectra, and the doublet NaI and M_gH_2 band, useful for studying the absorption spectra. Two expositions of 900 s were obtained for each target to remove cosmic rays. For the second run (data 2), we used a CCD detector with 750×1152 pixels of 22.5 μm, a 300 μm slit, a 900 l/mm grating in first order, and the same focus conversion previously described. The linear dispersion is 51 Å/mm, and the spectral resolution, $\Delta = 3.4$ Å. The covered wavelength range is 5724 $\leq \lambda \leq$ 7036 Å, centered in 6380 Å. This range includes H_α, N_{II}, and S_{II} lines, and the doublet NaI. We took two expositions of 1200 s for each target galaxy. A sample of late-type stars was also observed for radial velocity calibration with an exposition time of 10 s. Spectrophotometric stars were not observed, and our data could not be flux calibrated. Standard techniques of data reduction were applied to our data using IRAF. The extraction was done individually for each of the spectra. The tracing and sky subtraction was interactively obtained for each frame. After remotion of cosmic rays, the frames were combined to a single one. Wavelength calibration was done with He-Ar comparison lamp; afterwards, the spectra were normalized to the medium continuum.

3. Radial velocities

Whenever possible, we used both emission and absorption lines to determine our radial velocities. For that reason, we used *rvidlines* and *cross* IRAF tasks; the latter is based on Tonry & Davis' (1979) method. Our results for our second run, the

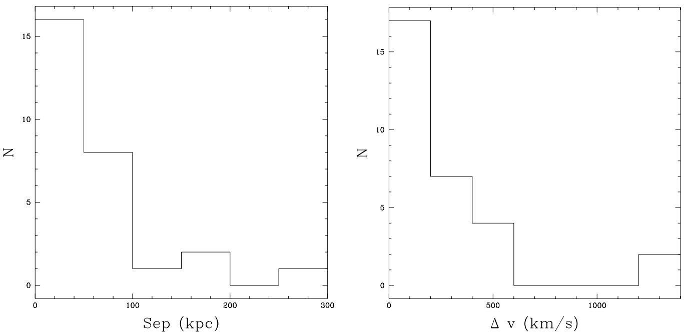

Fig. 1. Frequency of pair projected separation (Sep) and frequency of radial velocity difference (Δv) for our sample pairs.

one with better resolution, are shown in Table 1. We consider $H_0 = 100$ km s^{-1} Mpc^{-1}. In this table, the first column presents the object identification as it is described by Soares et al. (1995). A * symbol indicates that this galaxy was also studied in photometry (Couto da Silva & de Souza 2006). Columns 2 and 3 present the object identification and the radial velocity from ESO-LV catalogue (Lauberts & Valentijn 1989). Column 3 also exhibits other values for galaxy radial velocity when it was not available in the ESO-LV; in this column, BLA indicates data from Bergvall et al. (2003); dCa, da Costa et al. (1991); dCb, da Costa (1994; as published in Reduzzi & Rampazzo 1995); dCc, da Costa et al. (1998); dS, de Souza et al. (1997); F, Fisher et al. (1995); FJ, Fairall & Jones (1991); Lo, Loveday (1996); M, Mathewson et al. (1992); R., Ratcliffe et al. 1998; Sch., Schweizer (1987); and SWa, Sekiguchi & Wolstencroft (1992). Column 4 shows the radial velocity obtained using emission lines; Col. 5, the latter column value dispersion; Col. 6, the number of lines used to determine last column value; Col. 7, the radial velocity obtained using absorption lines; Col. 8, last column dispersion value; Col. 9, the number of lines used to get Col. 8; Col. 10, radial velocity obtained using cross-correlation method; Col. 11, last value dispersion; and Col. 12, the TDR value, which supplies the confidence degree of cross-correlation method used to get the radial velocity value (Tonry & Davis 1979). Larger TDR values indicate a best confidence for radial velocity determination.

Table 2 presents the radial velocities for the first run. Column representations are the same as for the previous table, but in Col. 3, di indicates di Nella et al. (1996) data. CS* indicates that this galaxy has a radial velocity determined in both runs; MF, Mathewson & Ford (1996); and SWb, Sekiguchi & Wolstencroft (1993). In fact, P221 is not a pair but a compact group; this group image and the galaxies associated with the letters a, b, c, and are shown in Couto da Silva & de Souza (2006). P268 is also a compact group (see more details in our previous work). It is interesting to point out that P280b was studied by Sekiguchi & Wolstencroft (1993), and that it is companion to another galaxy that is not P280a.

The distributions shown in Fig. 1 have a similar behavior of those obtained by de Souza et al. (1997) for a sample of binary galaxies from Soares et al. (1995). For nearly 86% of our sample galaxies the projected separation is <100 kpc. It means that our sample is mainly composed of close pairs, although there are some with larger projected separations. For the majority (~93%) of our pairs, $\Delta v < 600$ km s^{-1}. A similar distribution was found by Sekiguchi & Wolstencroft (1992), Chengalur et al. (1993), and de Souza et al. (1997). We consider that pairs with $\Delta v >$ 600 km s^{-1} are optical.

Table 1. Sample of binary galaxies.

1	2	3	4	5	6	7	8	9	10	11	12
Pair	Ident	V_{lit}	V_{emi}	σ	N_{lin}	V_{abs}	σ	N_{lin}	V_{cor}	σ	TDR
*P24a	I1562	3633	3759	5	5						
*P24b	I1561	3886	3889	11	5						
*P40a	N0348		8809	6	3				8824	43	5.5
*P40b	151 0180					7483	19	10	7498	60	6.2
*P42b	I1617	7970				7627	21	13	7774	34	7.7
*P101a	052 0200	8126 dCa	8121	19	3						
*P101b	052 0210		8184	9	2				8149	54	3.1
*P117a	I1813	4483	4480	7	5	4618	23	9	4536	64	6.7
*P117b	I1811	4821				4865	23		4768	84	5.0
*P139a	356 0220	6170	6161	4	3				6194	30	5.6
*P139b	356 0240	6124	6151	10	2				6126	107	3.8
*P316a	507 0450	4875				4864	14	11	4932	80	7.1
*P316b	507 0460	4602				4567	19	12	4626	81	6.8
*P323a	443 0500	5664 dS				5730	18	7	5713	110	5.1
*P331a	444 0101	9304 dS				9269	18	9	9316	54	5.9
*P331b	444 0100	9211	8837	5	2						
P350a	I4320	6827				6796	18	11	6774	99	4.7
P350b	509 1000	6567	6619	6	3						
*P358b	510 0580	2333	2286	11	5				2314	32	3.7
*P363a	511 0180	6395 dS	6336	7	3				6440	45	4.4
P373a	580 0430	6054				6112	16	9	6078	48	8.8
P373b	580 0410	2947 M	2961	4	5				2925	69	2.3
*P387a	I4935	4573 FJ				4575	20	9	4575	73	5.2
*P387b	143 0040	15218 BLA	15 206	9	3				15 298	72	6.0
*P402a	340 0150	6473				6519	11	10	6545	58	6.5
*P402b	340 0140		5209	4	6				5246	72	3.6
*P416a	I5020	3091				2931	24	8	3062	58	5.3
*P422a	463 0080	5988 SWa				6170	24	12	6024	69	4.8
*P422b	463 0091	6231 SWa	6438	5	3						
*P423a	N6935	4631				4543	18	11	4578	31	11.7
*P423b	N6937	4680	4777	6	5				4774	43	6.4
*P429a	I5042	4214	4143	3	4						
*P429b	I5038	4157	4110	6	4				4152	45	4.8
*P432a	I5063	3402	3369	13	4				3364	55	7.8
*P432b	I5064	3377	3310	6	33				3336	44	6.0
*P437a	286 0180	9162	9187	60	2	9131	27	9	9192	100	4.3
*P437b	286 0170	9664 dCb			3	9632	23	8	9773	59	5.2
*P457a	342 0220	12944 dCb	12 788	22	3				12 834	102	3.9
*P457b	342 0230	12924 dCb	13 126	06	3						
*P460a	I5101	5166	5140	1	3				5139	84	3.2
*P460b	I5100	5100 FJ	5077	2	5				5046	87	3.1
*P487a	N7125	3148 dCb	3140	10	5				3105	26	3.2
*P487b	N7126	2981	2948	10	5				2978	34	7.3
*P490a	048 0110	8208 F	8320	4	3				8291	64	5.4
*P490b	048 0120		8499	2	2				8497	64	4.0
*P497a	466 0240	5508 dCb	5298	9	4				5400	54	7.3
*P497b	I5149	5483	5518	11	4				5431	74	5.6
*P500a	288 0300	7891 SWa	7953	2	3				7999	49	2.4
*P500b	288 0320	8036 SWa	8173	9	3						
*P521a	404 0390	2624 dCb	2527	3	4				2636	42	8.4
*P538a	533 0210	11619 dCc				11 663	13	11	11 613	60	7.0
*P538b	533 0200	11611 dCc				11 603	22	7	11 604	91	4.5
*P539a	I5210	7329 dCb				7178	26	13	7244	56	7.9
*P539b	I5211	7382				7481	22	10	7382	87	6.2
*P546a	N7285	4347	4324	21	4	4208	22	12	4340	42	7.0
*P546b	N7284	4706				4681	18	8	4696	68	8.4

Table 1. continued.

1 Pair	2 Ident	3 V_{lit}	4 V_{emi}	5 σ	6 N_{lin}	7 V_{abs}	8 σ	9 N_{lin}	10 V_{cor}	11 σ	12 TDR
*P575a	076 0310					3735	12	13	3795	33	12.0
*P575b	076 0300	3750	3641	2	3				3643	39	8.1
*P616a	471 0340	8880 dCb				9038	21	9	8822	75	7.1
*P617a	111 0100	4829	4679		3				4774	46	6.6
*P617b	111 0090	4279	4203	4	2				4181	111	1.8

Table 2. Sample of probable binary galaxies (2).

1 Pair	2 Ident	3 V_{lit}	4 V_{emi}	5 σ	6 N_{lin}	7 V_{abs}	8 σ	9 N_{lin}	10 V_{cor}	11 σ	12 TDR
P67b	476 0180	5537 dCc	5706	11	3	5721	94	5	5703	140	7.4
P167a	418 0071	11052 dCc				11 326	9	3	11 310	129	7.2
P200b	549 0300	8534 MF				8519	52	3	8534	139	4.9
P215a	N1534	5341 dCa	5243	65	6	5168	59	4	5387	118	8.2
P215b	N1529					5122	33	5	5233	074	15.6
*P221a	420 0140	5573 dCc	5633	13	3						
*P221b	N1540		5522	17	6						
*P221c	420 0142	5565 dCc	5562	19	6						
P240a	203 0070	5376 dS				5368	13	2	5376	41	9.8
P240b	N1680	4316 dS				4241	15	2	4123	130	4.9
P247b	552 0320	6691 dCa	6696	18	3	6591	51	5	6651	133	8.1
P267a	486 0380	4156 dS				4195	37	5	4352	141	7.1
*P268a	486 0391		3842	13	5				4083	171	4.5
P270b	119 0460	4981 MF	5183	10	3	5276	59	4	5241	133	5.2
P273b	362 0170		3700	13	2				3797	150	2.8
P276a	305 0220	4627 dS	4583	9	5				4832	167	4.8
P280a	306 0030	4687 dS	4688	24	3	4653		1			
P280b	306 0011	11229 SWb				10 943	67	4	11 092	83	6.6
*P575a	076 0310	3735 CS*				3968	33	5	3952	72	11.2
*P594b	N7636	6797 di				7015	25	2	6964	95	9.4

We present data for 61 galaxies with spectral resolution $\Delta = 3.4$ Å (data 2), and 20 galaxies with spectral resolution $\Delta = 12$ Å. However, P575a was observed in both runs, and we were left with information for 80 galaxies. We noted that 53 of them belong to pairs, while 8 objects are components of optical pairs.

4. Special spectra

In this section we present our data for galaxies with peculiar spectra, such as Seyferts (Sys), LINERs, *N* galaxies, starbursts, or some galaxies previously studied by other authors. Our spectra were classified according to the emission lines relative strength recipe of Véron-Cetty & Véron (1986). However, our better resolution data does not reach the [OIII]λ5007 line, used for spectral classification of a galaxy, such as an Sy2, for instance. Due to that fact, we suggest the spectral classification of such galaxies as Sy2.

The Véron-Cetty & Véron (1986) spectral classification classifies the galaxies with enlarged Balmer lines as Seyfert 1 (Sy1); those with $H_\alpha < 1.2$[NII]λ6583 and [OIII]λ5007 $\gg H_\beta$ as Seyfert 2 (Sy2); those with $H_\alpha < 1.2$[NII]λ6583 and [OI]λ6300 $> 0.3H_\alpha$ as LINERs ; those with $H_\alpha < 1.2$[NII]λ6583 and no other line is showing (except by [SII]$\lambda\lambda$6717–6731), which do not allow us to discern between Sy2 and LINER, as *N*; and those with $H_\alpha > 1.7$ [NII]λ6583, as HII. It is important to emphasize that Filippenko & Terlevich (1992) claimed that a classical definition of LINER does not indicate an AGN because [OI]/$H_\alpha < 1.6$ relative strength might be explained by a photoionization model.

These spectra are showed in Figs. 2 and 3. All other spectra with better spectral resolutions are available in electronic form, but P538b, which has a very similar spectra to that of P538a, is not represented in these figures. Figures 2 and 3 are summarized as follows:

- **P117a (IC 1813):** *N*-type.
- **P139b:** *N*-type.
- **P422a:** Sekiguchi & Wolstencroft (1992, SWa forward) did not detect emission lines in this spiral. We confirm their result.
- **P422b:** SWa divided HII-region emission spectra into four subclasses. According to their subclass classification, this galaxy emission is of H_d type, where only H_α and/or [OII]λ3727 are detected. In our data, the [NII] emission is deblended. According to the Véron-Cetty & Véron (1986) spectra classification, this galaxy shows HII emission.
- **P432a (IC 5063):** *N*-type. This galaxy has been well studied, with more than 100 papers describing it. According to its spectral type, it is classified as Sy2 (Storchi-Bergman et al. 1990; Busko & Steiner 1992; Bonato et al. 1996).

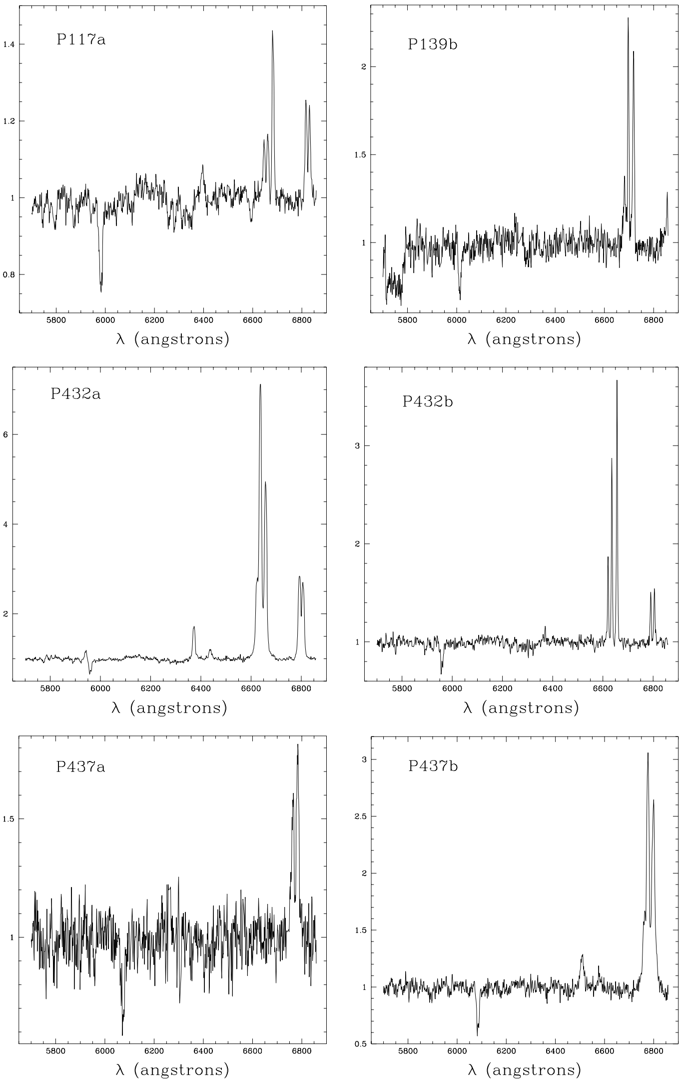

Fig. 2. Peculiar spectra of galaxies.

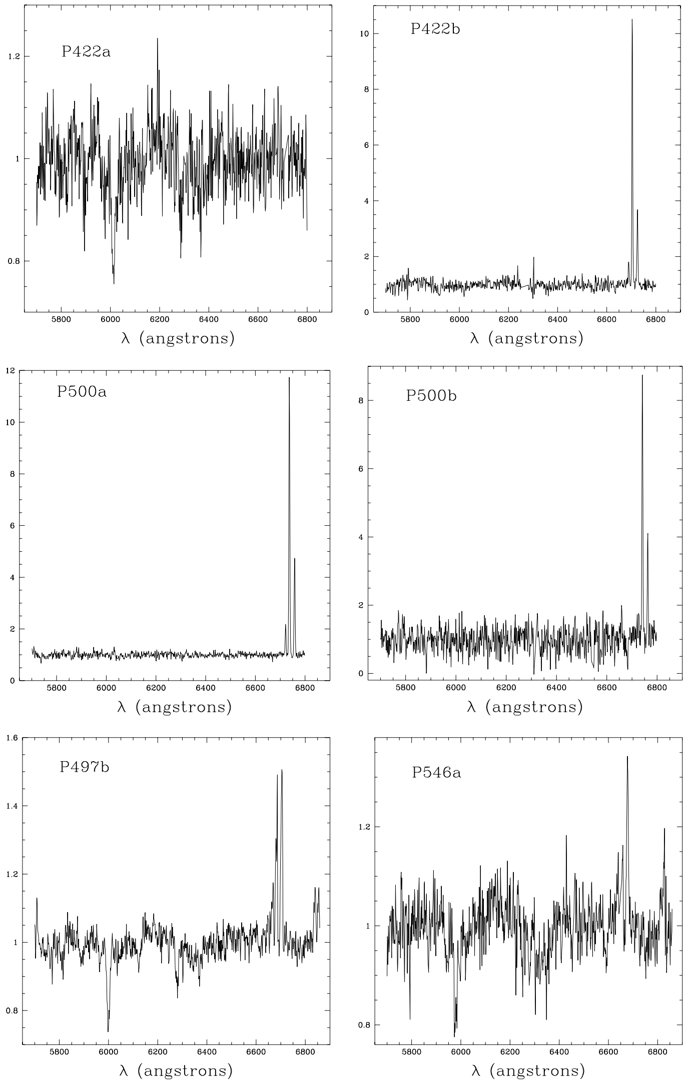

Fig. 3. Spectra of some galaxies.

- **P432b (IC 5064):** *N*-type. It is interesting to emphasize that both pair components exhibit a peculiar spectra.
- **P437a:** this galaxy was classified as LINER by Maia et al. (1987) and SWa, and as Seyfert by Lipovetsky et al. (1988). We can only classify it as *N*-type.
- **P437b:** Sy2 is our suggestion for this galaxy; its spectra is very similar to that of P432a. Sekiguchi & Wolstencroft (1992) classified it as LINER, but Donzelli & Ferreiro (1998) proposed that it is an Sy2. Note the similar behavior of this pair with P432: both pairs have AGN components.
- **P497b (IC 5149):** *N*-type.
- **P500a:** according to the SWa subclass classification, this object is of H_b type, where [NII]λ6583/H_α $<$ 0.7 and [OIII]]λ5007/H_β $<$ 1.0. We found the same relation for [NII]λ6583/H_α relative strength, but we cannot confirm their findings for [OIII]]λ5007/H_β because our spectra does not reach that wavelength range. This galaxy shows strong emission lines. However, Bergvall & Johansson (1995) obtained a spectra with no emission lines for this object (ESO 228-G30) in the range $\lambda\lambda$6500−7000 Å.
- **P500b:** according to SWa, the spectra of this galaxy is of H_c type, where weak lines of H_α and [NII]λ6583 are detected. Bergvall & Johansson (1995) also detected H_α and [NII]λ6583 emission lines in this galaxy (ESO288-G32).
- **P546a (NGC 7285):** Keel et al. (1985) classified this galaxy as LINER. We can only classify it as *N*-type.
- **P546b (NGC 7284):** like Keel et al. (1985), we did not detect emission lines in this elliptical galaxy.

As was already mentioned, our analysis takes into account only the data obtained with spectral resolution 3.4 Å. In this sample, we detected 8 out of 53 binary galaxies with peculiar spectra: P117a, P139b, P432a, P432b, P437a, P437b, P497b, and P546a. According to the Véron-Cetty & Véron (1986) spectral classification, we can only classify these galaxies as *N* spectral type. However, we believe that 5 of them (P117a, P139b, P432a, P437a, and P437b) are Seyfert. If this suggestion is confirmed, the percentage of Seyfert galaxies in our sample is ∼11%. We consider these galaxies as Seyferts instead of LINERs due to the broad emission lines in their spectra. Three of these galaxies, P432a, P437a, and P437b, are cited as Seyferts in the literature; however, we do not suggest that P432b is Sy, but that it is LINER, although it has both citations in previous works. According to the literature, there are 4 Sys in our sample, and according to our suggestion there are 5. We must remember that the field galaxies sample cited in the literature is only composed of disk galaxies. Excluding the 4 ellipticals from our binary sample, we are left with 49 disk galaxies. According to previous

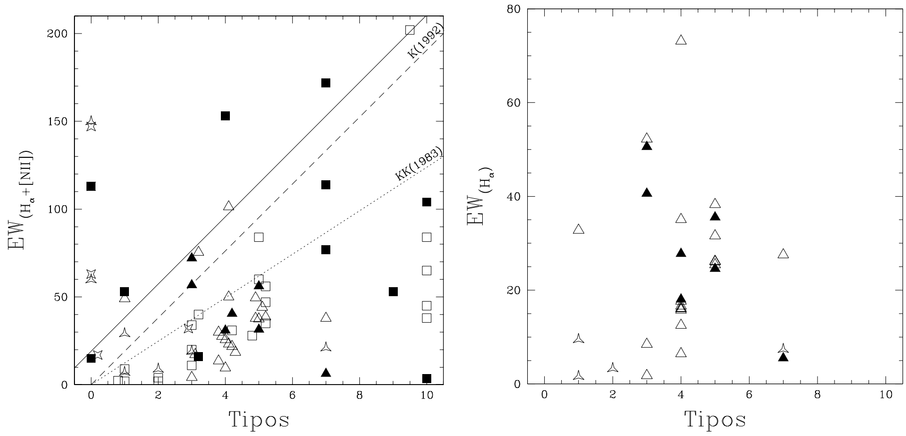

Fig. 4. In both figures, open triangles represent our data for galaxies with non-peculiar morphologies; bold triangles, the data for galaxies with peculiar morphology; and starry triangles, the ones for objects with peculiar spectra. Figure 4a presents the variation of *EW* (H_α + [N_{II}]) with morphological type. In this figure open squares represent field galaxies' integrated spectra data from Kennicutt (1992, hereafter K 92); bold squares, K(92) data for strongly interacting galaxies; and starry squares, K(92) data for Seyfert galaxies. The behavior of field galaxies with 5−7 Å resolution integrated spectra from Kennicutt (1992, hereafter K 92) is presented with a broken line. The dotted line shows the behavior of *EW* (H_α + [N_{II}]) for the integrated spectra of field galaxies from Kennicutt & Kent (1983, hereafter KK 83). The solid line indicates a trial upper limit for our sample galaxies that may not show emission line strength excess. This line is parallel and encompasses the one which represents K92 data of integrated emission because the latter is diluted over a larger region. Figure 4b presents the variation of *EW* (H_α) with morphological type.

publications, there are 4/49, or an ∼8% fraction of Sys in our sample; and according to our suggestion, that number is 5/49, or ∼10%. These values are similar to the fraction of Seyferts found by Keel et al. (1985) for pair components: ∼10.5% for the complete sample and ∼8% for the Arp sample. Our values are slightly larger than the ∼5.5% number of Sys of the Keel (1983) disk field galaxies control sample. According to Keel et al. (1985) recipe the number of galaxies in our sample cited as Sys in the literature is significant at the 1σ, while those that we proposed are significant at the 2σ. It is important to emphasize that if P432b is classified as Sy instead of LINER (as cited in the literature), our suggestion number of Seyferts becomes 6/49 (∼12%), a more significant fraction. If we compare our fraction of probable Sys with the ∼4.6% fraction for isolated field spirals from Dahari (1985), the results become still more significant. In spite of dealing with a small number of pair components we suggest that there is an enhancement in number of Seyferts in our binary sample, as was proposed by Keel et al. (1985) for their sample of paired galaxies. Barton et al. (2000) noted that ∼13% of their close pairs sample have emission line ratios consistent with Sys or LINERs. In our sample, there are ∼15% (8/53) Sys or LINERs, a fraction similar to the one obtained by Barton et al. (2000), but much less than the ∼41% number of AGNs found by Veilleux et al. (1995) for their sample of luminous infrared galaxies (LIRGs). According to Barton et al., these differences may occur because infrared selection favors late-stage mergers, dusty mergers, and merger remnants, whereas blue selection favors younger star-forming systems. Only 2 (P139b and P437a) out of 8 AGNs from our sample show morphological distortion: P139b has tails and P437a is a warped spiral.

Our sample was randomly chosen from Soares et al. (1995) and was only limited by observing time and weather conditions. We may consider this sample as being mainly composed of pairs of relatively comparable sized galaxies, as was the Sekiguchi & Wolstencroft (1992) sample. Most (but not all) of our pairs are undergoing strong interaction. Nevertheless, Dahari (1985), SWa (1992), Donzelli & Pastoriza (1997), and Liu & Kennicutt (1995) found a deficiency of AGNs among interacting or merging systems compared to field spirals. Donzelli & Pastoriza (1997) suggested that the HII-region spectra may dilute the AGN spectra when the observations are performed with low spatial resolution and that high spatial resolution observations are needed to resolve the inner 1 kpc of galaxies.

5. Central optical emission

Kennicutt & Kent (1983, forward KK 83) argued that the emission lines from field galaxies integrated spectra increase smoothly with the Hubble sequence. However, the dispersion of every morphological type is very large. The dispersion may also be related to variations in morphological classification. According to KK 83, there is not a clear correlation between nuclear and integrated emission lines. For these authors, the large dispersion in emission lines, represented by *EW* (H_α + [N_{II}]), is related to disk instead of nuclear formation that they believe is hardly significant.

As we have morphological classification of good quality for most of our sample galaxies (all but these belonging to pairs P350 and P373) based on structure analysis (Couto da Silva & de Souza 2006), we can use them to assess how the Hubble sequence relates to central optical emission in our sample. As was previously mentioned, only medium resolution spectra are used to obtain the *EW* (H_α + [N_{II}]). Main galaxy information is presented in Table 3. In this table, Col. 1 indicates the Soares et al. (1995) pair number; Col. 2, galaxy identification; Col. 3, radial velocity; Col. 4, total *B* apparent magnitude (ESO-LV catalogue); Col. 5, morphological classification from Couto da Silva & de Souza (2006), except for pairs P350 and P373 with a morphological type from the RC3 (de Vaucouleurs et al. 1992); Col. 6, projected separation (kpc); Col. 7, *EW* (H_α + [N_{II}]) (Å); and Col. 8, *EW* (H_α) (Å).

Figure 4 shows the behavior of our data after the exclusion of optical pairs. We used the following numbers to represent morphological types on the *x*-axis of Figs. 4a and b: Sa = 1, Sab = 2, Sb = 3, Sbc = 4, Sc = 5, Scd = 6, S = 7, Sd = 8, Sm = 9, and Im = 10. Ellipticals are not represented in these figures because we did not detect emission lines in their central region.

Table 3. Central optical emission.

1 Pair	2 Ident	3 Vel	4 B_T	5 Class	6 Sep(Kpc)	7 $EW_{(\mathrm{H}\alpha+[\mathrm{NII}])}$	8 $EW_{(\mathrm{H}\alpha)}$
P24a	I1562	3633	13.56	S(s)c	43	44.14	26.05
P24b	I1561	3886	14.92	SB(s)bc		101.38	73.15
P40a	N0348	8809 CS	14.58	SB(s)bc	–	23.37	16.53
P40b	151 0180	7498 CS	14.80	S(s)a			
P42b	I1617	7970	14.59	S(s)a	141		
P101a	052 0200	8126 dCa	14.58	S(s)c p	32	31.48	24.58
P101b	052 0210	8184 CS	14.97	SB(s)bc		25.69	17.69
P117a	I1813	4483	14.20	S(s)a	46	7.07	1.63
P117b	I1811	4821	14.35	SB(r)a			
P139a	356 0220	6170	13.30	SB(r)c	262	37.46	26.14
P139b	356 0240	6124	14.83	S p		21.02	7.36
P316a	507 0450	4875	12.84	E3 p	30		
P316b	507 0460	4602	13.96	S0			
P323a	443 0500	5713 CS	14.49	E2	44		
P331a	443 0500	9211 dCb	14.33	SB(s)a p	23		
P331b	444 0100	9211	15.43	S(s)bc p		30.96	18.03
P350a	I4320	6827	14.25	S0?(RC3)	160		
P350b	509 1000	6567	15.13	S? (RC3)		37.91	27.54
P358b	510 0580	2333	14.06	SB p		6.35	5.53
P363a	511 0180	6440	14.51	SB(r)bc	43	27.62	15.74
P373a	580 0430	6054	13.79	S0 p(RC3)	–		
P373b	580 0410	2947 M	14.32	S bc?(RC3)		33.07	26.97
P387a	I4935	4575 CS	14.04	SB(r)a	–		
P387b	143 0040	15298 CS	15.19	SB(s)bc		22.08	12.34
P402a	340 0150	6473 CS	13.59	E2 p	–		
P402b	340 0140	5246 CS	14.74	S(rs)a p		87.09	59.06
P416a	I5020	3091	12.95	S(s)bc	67		
P422a	463 0080	5988 SWa	14.43	SB(r)a	19		
P422b	463 0091	6231 SWa	15.14	S(s)b p		56.76	40.61
P423a	N6935	4631	12.77	S(r)a	61		
P423b	N6937	4680	13.37	SB(r)c		49.54	31.61
P429a	I5042	4214	14.06	S(s)bc	87	13.58	
P429b	I5038	4157	14.22	SB(s)bc		21.80	16.10
P432a	I5063	3402	12.92	S0 p	107	149.79	
P432b	I5064	3377	14.31	SB(s)a		29.10	9.48
P437a	286 0180	9162	14.30	S(s)b p	36	19.12	
P437b	286 0170	9664dCb	14.49	SB0		59.76	
P457a	342 0220	12944 dCb	14.60	SB(r)b	64	75.41	52.22
P457b	342 0230	12924 dCb	15.31	S(s)c p		56.16	35.54
P460a	I5101	5166	14.04	SB(s)bc p	88	40.47	27.78
P460b	I5100	5100 FJ	14.61	SB(s)c		37.92	27.59
P487a	N7125	3148	12.70	SB(r)c	55	38.62	25.44
P487b	N7126	2981	12.99	S(r)b		4.18	1.79
P490a	048 0110	8320 CS	14.7	SAB(s)bc	22	29.97	16.60
P490b	048 0120	8499 CS	16.25	S(s)b:		17.15	8.47
P497a	466 0240	5431 CS	13.8	S(r)bc	170	23.27	16.10
P497b	I5149	5483	14.50	SB(s)ab		8.89	3.28
P500a	288 0300	7891 SWa	14.71	S(s)b p	30	72.02	50.59
P500b	288 0320	8036 SWa	14.95	SB(s)bc		50.00	35.06
P521a	404 0390	2624 dCb	14.27	SB(s)b		21.79	13.26
P538a	533 0210	11613 CS	14.32	S0 p	18		
P538b	533 0200	11604 CS	14.74	S0 p			
P539a	I5210	7329 dCb	14.01	E1	62		
P539b	I5211	7382	14.66	S(s)a			
P546a	N7285	4347	12.82	SB(r)b	6	5.21	
P546b	N7284	4706	12.96	E3			

Table 3. continued.

1 Pair	2 Ident	3 Vel	4 B_T	5 Class	6 Sep(Kpc)	7 $EW_{(H\alpha+[NII])}$	8 $EW_{(H\alpha)}$
P575a	076 0310	3795 CS	13.96	S0	48		
P575b	076 0300	3750	14.20	SB(s)a		48.98	32.78
P616a	471 0340	8880 dCb	14.33	SB(s)a	91		
P617a	111 0100	4829	14.18	SB(s)bc	21	18.50	12.50
P617b	111 0090	4279	14.65	S(s)bc		9.63	6.44

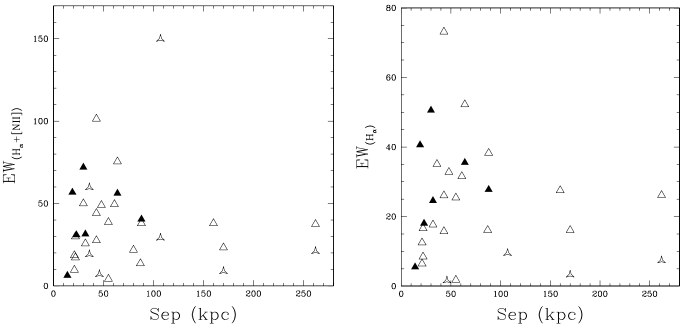

Fig. 5. These figures relate $EW\,(H_\alpha + [N_{II}])$ and $EW\,(H_\alpha)$ with projected separation. As before, open triangles represent our data for galaxies with non-peculiar morphologies; bold triangles, the data for galaxies with peculiar morphology; and starry triangles, the ones for objects with peculiar spectra.

Figure 4a shows the behavior of $EW\,(H_\alpha + [N_{II}])$ as a function of morphological type. Few galaxies of our sample show a high *EW* (H_α + $[N_{II}]$) strength. It is interesting to note that the S0 galaxies displaying central optical emission lines are only these with peculiar spectra (Seyfert or LINER). Figure 4b presents the variation of *EW* (H_α) with morphological type. There is a slight trend of Sb-Sbc galaxies presenting a larger *EW* (H_α) strength. Sekiguchi & Wolstencroft (1992) data also shows a slight trend for a larger central emission of Sb galaxies, but these authors did not note that. It is important to enlarge the spectra sample of spiral galaxies with good morphological classification to determine whether this trend is real. If it is confirmed, then binary galaxies' central emission might be related to bulge size and to intrisic gaseous amounts in galaxies.

Figure 5a presents *EW* ($H_\alpha + [N_{II}]$) variation with pair projected separation (kpc). For pair components with Sep > 100 kpc, *EW* (H_α) strength does not reach 50 Å. However, not all galaxies belonging to close pairs (Sep < 70 kpc) show *EW* > 50 Å. It is noteworthy to emphasize that all but one of our sample galaxies with *EW* (H_α + $[N_{II}]$) > 50 Å are components of close pairs. The one belonging to a pair with Sep ∼ 100 kpc is an Sy2 galaxy (P432a). KK83 proposed that galaxies with *EW* (≥50 Å) for the integrate spectra are undergoing episodes of strong star formation. Figure 5b shows the same trend presented by Fig. 5a: components of close pairs have more chances of exhibiting an excess in central optical H_α emission; however, not all of our sample galaxies present that trend. Lambas et al. (2003) verified that star formation in galaxy pairs with projected separation <25 kpc and velocity separation <100 km s^{-1} is significantly enhanced over that of isolated galaxies with similar redshifts. However, they noted that ~45% of galaxy pairs do not show signs of important star formation activity, supporting the hypothesis that the internal properties of galaxies play a crucial role in triggering star formation for galaxies in interaction. Our results may be considered an extension of Lambas et al. (2003) findings. Our results also corroborate the findings of Bushouse et al. (1988), who verified that many interacting galaxies do not show central emission.

6. Discussion

In spite of having a small sample, a statistical analysis of our binary galaxies sample can be made, and we can assess their behavior concerning morphologies, frequency of bars, and mean emission lines. We obtained spectroscopic information for both components of each one of the 24 pairs with better resolution data. For 7 pairs, we only obtained data for one component. Including morphological information for companions of these galaxies, we were left with 60 binary galaxies that can be analyzed with respect to their morphological types, but only 53 galaxies can be analyzed using spectroscopic data. One of our sample galaxies, P437a, is a very edge-on spiral. The classification we adopted for this spiral is S(s)b; however, the presence of a bar within it cannot be excluded, although it was not clear either. A better classification for this galaxy should be SB?(s)b. For this analysis we considered P42a as SB(r)bc, P323b as SBb, P358a as SBcd, P363 as Sb, P416b as SBcd, P616b as SABR0, and P521b as S0. Our sample, randomly chosen from the Soares et al. (1995) binary galaxies list, is composed of 4 elliptical galaxies, 7 (9) lenticulars, 10 Sas, 1 Sab, 8 (10) Sbs, 13 (14) Sbcs, 7 Scs, (2) Scds, and 3 simply classified as S (spiral), due to their severe morphological distortions. Numbers within parentheses indicate the morphological type of the 7 galaxies previously discussed (7 companions to galaxies studied in this sample). These galaxies were included only to obtain statistics related to the morphological types, but they were not taken into account when spectroscopic information was necessary. Thus, we considered a total of 60 objects for this analysis. The number of S0 galaxies is nearly the same as that of Sa and Sb galaxies, however, the occurence of ellipticals (and Sab and Scd galaxies) is very small. In our sample, 21.5% of galaxies are classified as E or S0, 18.5% as Sa or Sab, 40% as Sb or Sbc, and 15% as Sc or Scd galaxies (5% are classified as S). The majority of early-type components of our binary sample are lenticular galaxies, while Sb-Sbc galaxies are the most common types in our sample. A slight enhancement of Sb galaxies in pairs is also found in Sekiguchi & Wolstencroft (1992), but these authors did not note that. It seems that, when ranged together, Sb-Sbc are the most common spiral types in comparably sized binary samples at the present epoch, unless we believe there is a special reason for their occurrence in these samples.

Information relating to the number of barred and unbarred galaxies and mean *EW* (H_α + $[N_{II}]$) emission line strength for disk galaxies are presented in Table 4. Column 1 displays the morphological type; Cols. 2 and 3 show the number of galaxies morphologically classified as unbarred (SA) and barred (SB). P490a, an SABbc galaxy, is not included in this table. Mean

Table 4. Mean central optical emission strength for barred and unbarred disk galaxies.

1 Type	2 SA	3 SB	4 SA $EW(H_\alpha + [N_{II}])$ (Å)	5 SB $EW(H_\alpha + [N_{II}])$ (Å)	6 All $EW(H_\alpha + [N_{II}])$ (Å)
S0	6	1	25.0 ± 25.0	59.76	29.9 ± 21.7
Sa	4	6	1.8 ± 1.8	13.0 ± 8.6	8.5 ± 5.3
Sab	–	1	–	8.9	8.9
Sb	5	3	33.8 ± 13.0	34.1 ± 21.2	34.0 ± 10.4
Sbc	5	7	15.5 ± 5.4	40.8 ± 10.9	30.2 ± 7.5
Sc	3	4	43.9 ± 7.1	40.9 ± 2.9	42.2 ± 3.2
Sp	2	1	29.5 ± 8.4	6.35	21.8 ± 9.1

EW (H_α + [N_{II}]) emission line strengths are presented in Cols. 4 and 5. Column 6 presents mean emission line strength for every morphological type, considering barred and unbarred galaxies together.

We corroborate Liu & Kennicutt's (1995) and Donzelli & Pastoriza's (1997) findings that the morphological types of interacting galaxies are related to their spectral characteristics. The same trend was obtained by Kennicutt & Kent (1983) for the field galaxies integrated spectra. Ho et al. (1997) noted that the frequency of [H_{II}] in the nuclear region of isolated galaxies is a strong monotonic function of morphological type, increasing from 0% in elliptical galaxies to 8% in lenticular galaxies, 22% in Sa galaxies, 51% in Sb galaxies, and 80% in Sc-Im galaxies, although these frequencies may be influenced by AGN contamination. We did not detect emission lines in the elliptical galaxies of our sample. The 2 lenticular galaxies, out of 7 exhibiting EW (H_α + [N_{II}]) emission lines, are AGNs (P432a and P437b), one barred and the other unbarred. Nearly 2/3 of Sa galaxies also do not exhibit central emission. However, the SBa type presents a larger mean strength than the Sa type in spite of its small mean strength. In the same way, the SBbc type presents a larger central emission than that of the Sbc type, but the mean strength for this type is smaller than the strength of the next class of early and late-spiral types. If this were caused by a misclassification of these galaxies, the Sbc type probably belongs to a morphological type next to them with a larger mean emission strength. A comparison between the morphological types used in this work and other morphological classifications, such as those from the RC3 catalogue, indicates that this is not the case. In spite of the small number of galaxies present in this analysis, it is noteworthy to mention that the occurrence of SBbc is more than twice that of Sbc. The number of spirals with a morphological type later than Sc is very small, only two, and both are barred; no spectroscopic data was obtained for them in this work. There is a small difference between pairs studied in this sample and the one studied in photometry by Couto da Silva & de Souza (2006), but the results are nearly the same.

Donzelli & Pastoriza (1997) studied a sample of pairs consisting of a main galaxy (component A) and a companion with half or less the diameter of the main component (B component), and they noted that A components show a mean strength of EW (H_α + [N_{II}]) $\sim$ 37 Å, a slightly higher strength than the 29 Å obtained by KK 83 for normal spiral galaxies (the mean strength for EW (H_α + [N_{II}]) for our sample of spiral components of optical pairs is ~27 Å). According to Donzelli & Pastoriza, B components show a significantly enhanced strength (54 Å) compared to A components and to isolated galaxies. However, Lambas et al. (2003) verified that the effects of having a companion are more significant on the star formation of bright galaxies in pairs, unless the pairs are formed by similar luminosity galaxies; in this case, the star formation is enhanced in both components.

The mean EW (H_α + [N_{II}]) strength for A and B components in our sample is 23.4 ± 4.9 Å and 30 ± 5.4 Å, respectively, considering only spiral + spiral pairs. The errors presented in this work are the mean standard errors. This indicates that the star formation activity is most likely to take place in both galaxies with nearly the same mean strength, although it is slightly higher for B components. This might be related to the fact that our pair components show either a large morphological type similarity (see below) or a similar luminosity, as pointed out by Lambas et al. (2003). For A components, the mean strength is slightly lower than that obtained for isolated spirals by KK 83, as well as for optical pairs of this work. The mean strength for B components is around the one obtained for isolated galaxies, although it may be slightly different because we did not make an absorption effect correction. However, this may not affect our results much.

We corroborate the Bergvall et al. (2003) findings that there is not a significant enhancement in star formation of interacting/forming galaxies. A possible explanation for the differences found in the literature may be associated with different samples taken into account. We noted that in binary galaxies, the emission is related to the galaxy morphology. In our sample, the spirals with types in the range of Sb-Sc galaxies are stronger emitters (we did not observe galaxies Scd and later). If a sample contains more galaxies with morphological types in that range, for instance, the results may indicate a larger mean emission strength. Results based on mean values may be tendentious as well. Just two out of seven lenticulars present optical central emission, and they are both AGNs. These 2 galaxies are responsible for the large mean EW (H_α + [N_{II}]) strength obtained for the lenticulars. If they are excluded from the sample, we should conclude that no one lenticular is a central emitter. All Sbc galaxies but P416a, a flocculent spiral, are central emitters. It would be interesting to obtain EW information on a large sample of pair components ranged in different spiral classes to better differentiate between intrinsic star formation enlargement and that caused by gravitational interaction.

P402b (type S(rs)a p), an optical pair component, shows some very interesting behavior. It presents a very blue central region, a boxy-shaped bulge (Couto da Silva & de Souza 2006), and a strong central HII emission, but it is not a pair component. Perhaps it had an unbound encounter with P402a sometime in the past. As this galaxy does not have a bar, a bar cannot be evoked as the mechanism responsible for driving the gas inward. This interesting object deserves deeper study. Eight galaxies of our sample belong to optical pairs (P40, P373, P387, P402): 1 E, 1 S0, 3 Sas, 1 Sbc, and 2 SBbcs. The elliptical and the lenticular galaxies of these optical pairs do not show emission, and two out of the three Sa galaxies do not show emission lines either. However, the P402b makes the mean EW (H_α + [N_{II}]) strength for Sa galaxies become ~29 Å, a larger mean strength than the one obtained for pair components. For one Sbc this strength is ~33 Å, and for 2 SBbcs galaxies it is ~23 Å. Of course, we are dealing with uncomfortably small numbers.

Malkan et al. (1998) pointed out that galaxies with HII emission line spectra appear more irregular and clumpy because of their higher rates of current star formation per unit of galactic mass. We looked for morphological peculiarities in our sample for galaxies with EW (H_α + [N_{II}]) $\geq$ 50 Å, excluding the AGNs. Galaxies that match these criteria are: P24b, P422b, P457a, P457b, P500a, and P500b, all spirals with types equal to or later than Sb. These galaxies present either a bar or an inner peculiarity. P24b, P457a, and P500b are barred spirals. P422b has a very displaced center, P457b exhibits an inner knot of star formation, and P500a has a strong inward peculiarity: a displaced center and a structure (bar?) being formed or extinguished (Couto da Silva & de Souza 2006). However, not all spirals exhibiting either an inner morphological distortion or a bar display a high HII central emission line spectra. This is the case of P101a and P358b, both unbarred galaxies presenting an inward peculiarity, but with a central optical emission in the range foreseen for its morphological type. Nevertheless, P101a is a far ultraviolet emitter (Bowyer et al. 1995), thus it may be a strong emitter in a different spectra range than that studied in this work. In P457 and P500, both components present an excess in their star formation. It is interesting to note that both pairs have a morphological peculiar spiral paired with a barred spiral. It is important to keep in mind that P402b, an unbarred component of an optical pair, shows a very peculiar morphology and is a strong central optical emitter. In this case, the strong emission is associated with the peculiar morphology, but not with the gravitational interaction.

Rampazzo et al. (1995) found evidence that for some mixed pairs, the gaseous material of the early-type galaxy might be obtained from the spiral component through a cross-fueling mechanism. Domingue et al. (2003) also studied a sample of mixed pairs, and they found that many early-type galaxies exhibit weak *EW* emission. However, some early-type components of their sample, especially the lenticular galaxies, show evidence of significant star formation, with *EW* (H_α) strength comparable to or exceeding that of spiral components. There are 11 early-type galaxies in our sample, 4 ellipticals, and 7 lenticulars. One elliptical belongs to an early pair E/S0, and the cross-fueling mechanism cannot act on it or on the lenticular. Three of them are paired with spirals, but we did not detect emission in any of them, even in P546b, which is a component of a very close pair. Keel et al. (1985) and Liu & Kennicutt (1995) did not detect emission lines in P546b either. Three lenticulars are components of early-type pairs: one belongs to an E/S0 pair, and two of them to S0/S0 pairs. The remaining 4 lenticulars are components of S0/S pairs where a cross-fueling mechanism should be evoked to trigger star formation in these galaxies. The two lenticular galaxies with *EW* (H_α + [N_{II}]) emission show a strength that exceeds that of spiral components (P432 and P437); however, both are AGNs and their spiral companions are also AGNs. These pairs are at different relative separations, and it does not seem that the cross-fueling mechanism can be responsible for triggering the active galactic nuclei in both components of these pairs. It is important to emphasize that the Domingue et al. (2003) sample was selected by infrared emission in a different way than selections made in this work. For almost all early-type galaxies of our sample, we did not detect emission spectra, in accordance with Liu & Kennicutt (1995) and Donzelli & Pastoriza (1997) findings that the morphological types of interacting galaxies are related to their spectral characteristics.

To have a rough idea how binary galaxies components are connected to their companions, we applied the same pairing factor, Δp, used in our photometric sample (Couto da Silva & de Souza 2006) to our spectroscopic sample. It is important to emphasize that these samples are slightly different, mainly because of weather conditions. For pairs with an elliptical component, $\Delta p = 2.3 \pm 0.5$, for $N = 4$. This indicates that an elliptical galaxy has a trend of being paired with spiral types no later than Sb, in spite of individual differences. However, the small number of elliptical galaxies in our sample does not make this result reliable. For pairs with a lenticular component, $\Delta p = 1.3 \pm 0.3$. This suggests that lenticulars prefer having E or Sab galaxies as companions ($N = 8$, as P538 was counted once and P350 was not included in this analysis). If we take only spiral-spiral pairs ($N = 17$, as P139 and P358 were excluded from this analysis since they contain an S component) into account, $\Delta p = 0.8 \pm 0.1$, indicating that a spiral has a tendency of being paired with another spiral of similar morphology. There is still a close correlation among morphological types. These results corroborate the works of Karachentsev (1990) and Couto da Silva & de Souza (2006), whicht found a morphological similarity between the pairs' components.

7. Conclusions

Some galaxies in our sample exhibit strong central star formation detected both in our $B-R$ color maps (Couto da Silva & de Souza 2006) and in this spectroscopic study. Most of these galaxies belong to close pairs; however, not all galaxies belonging to close pairs show this behavior. Disregarding the galaxies with peculiar spectra, we noted that the galaxies exhibiting an excess in their central optical emission either have a bar or an inner morphological peculiarity. That may be an indication that besides interaction, other agents such as particular internal conditions (Petrosian et al. 2002; Lambas et al. 2003), gaseous feeding due to kinematical mechanisms (Keel et al. 1985; Bushouse et al. 1988), orbital geometry (Jones & Stein 1989; Surace et al. 1993), and dust content (Jones & Stein 1989) can trigger emission in binary galaxies. According to Mihos & Hernquist's (1996) models, the gas response to a close pass depends dramatically on the mass distribution of a galaxy.

In agreement with Keel et al. (1985), we suggest that there is a slight enhancement in AGNs in our binary sample, although it is much smaller than the number of AGNs in a sample of LIRGs. Only 2 (P139b and P437a) out of 8 AGNs from our sample show morphological distortion, and our data indicates that AGNs' peculiar spectra are not associated with any morphological peculiarity. It is interesting to note that a galaxy with peculiar spectra (P139b, probably a LINER) belongs to a pair with projected separation >250 kpc. In this case, the proximity between galaxies is not the mechanism responsible for triggering the spectral peculiarity.

We corroborate Liu & Kennicutt's (1995) and Donzelli & Pastoriza's (1997) findings that the morphological types of interacting galaxies are related to their spectral characteristics. In spite of having a few mixed pairs in our sample, we do not corroborate Rampazzo et al.'s (1995) and Domingue et al.'s (2003) findings that in such pairs the gaseous material of the early-type galaxy is obtained from the spiral, unless we believe that either all ellipticals of our sample are exceptions or that the emission of these galaxies is only detected in the infrared spectral range. Only two out of seven lenticular galaxies' components of mixed pairs present a strong central optical emission, and they are both AGNs.

We found a large morphological similarity between pair components, just as Karachentsev (1990) and Couto da Silva & de Souza (2006), for a slightly different sample, did. In our binary sample of relatively comparable sized galaxies, we verified that the star formation activity is most likely to take place in both galaxies with nearly the same mean strength. This might be related to the fact that our pair components show either a large morphological type similarity or a similar luminosity (Lambas et al. 2003).

It seems that, ranged together, Sb-Sbc are the most common spiral types in comparable sized binary samples at the present epoch. As the median population of field galaxies is Sb (Schweizer & Seitzer 1992), we may infer that the population of pairs of galaxies is an extension of that of the field.

Our result is in agreement the one found by Bushouse et al. (1988), who verified that many interacting galaxies do not show nuclear emission. It is important to keep in mind that P402b, an unbarred component of an optical pair, shows a very peculiar morphology and is a strong central optical emitter. In this case, the emission is associated with the peculiar morphology but not with the gravitational interaction.

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Online Material

Appendix A: Catalog of optical spectra for a sample of galaxies

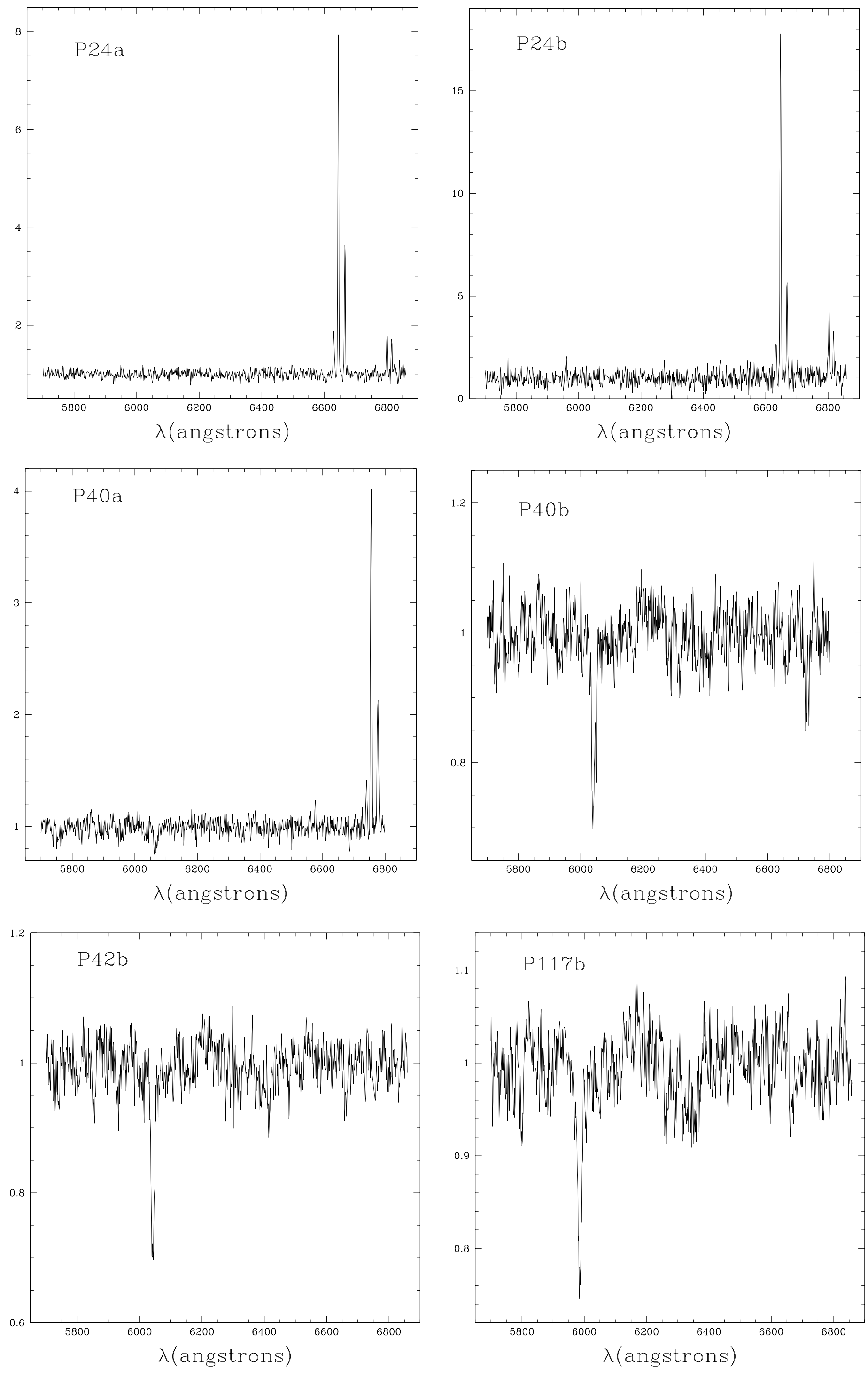


Fig. 3. Spectra of some galaxies.

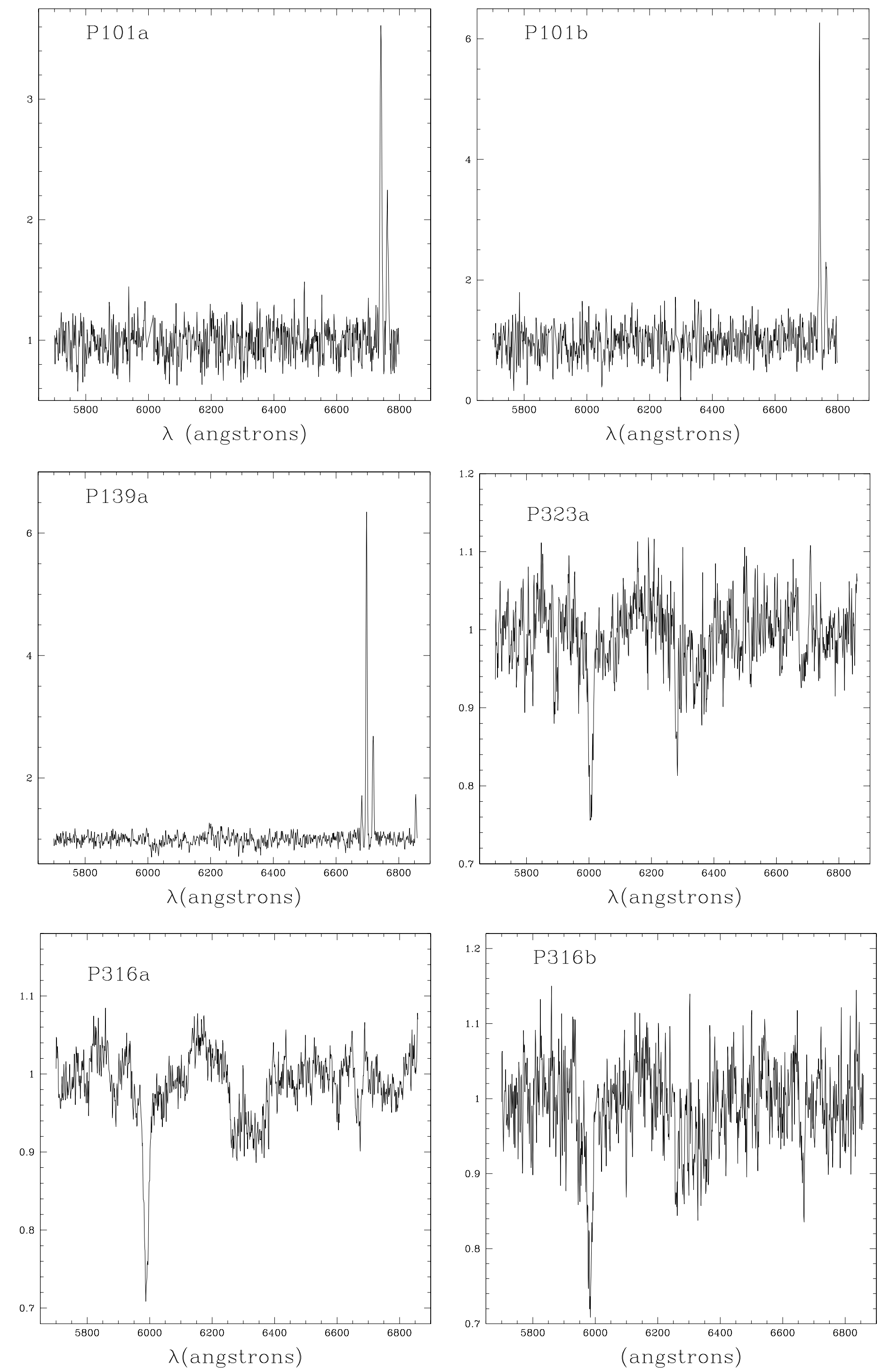
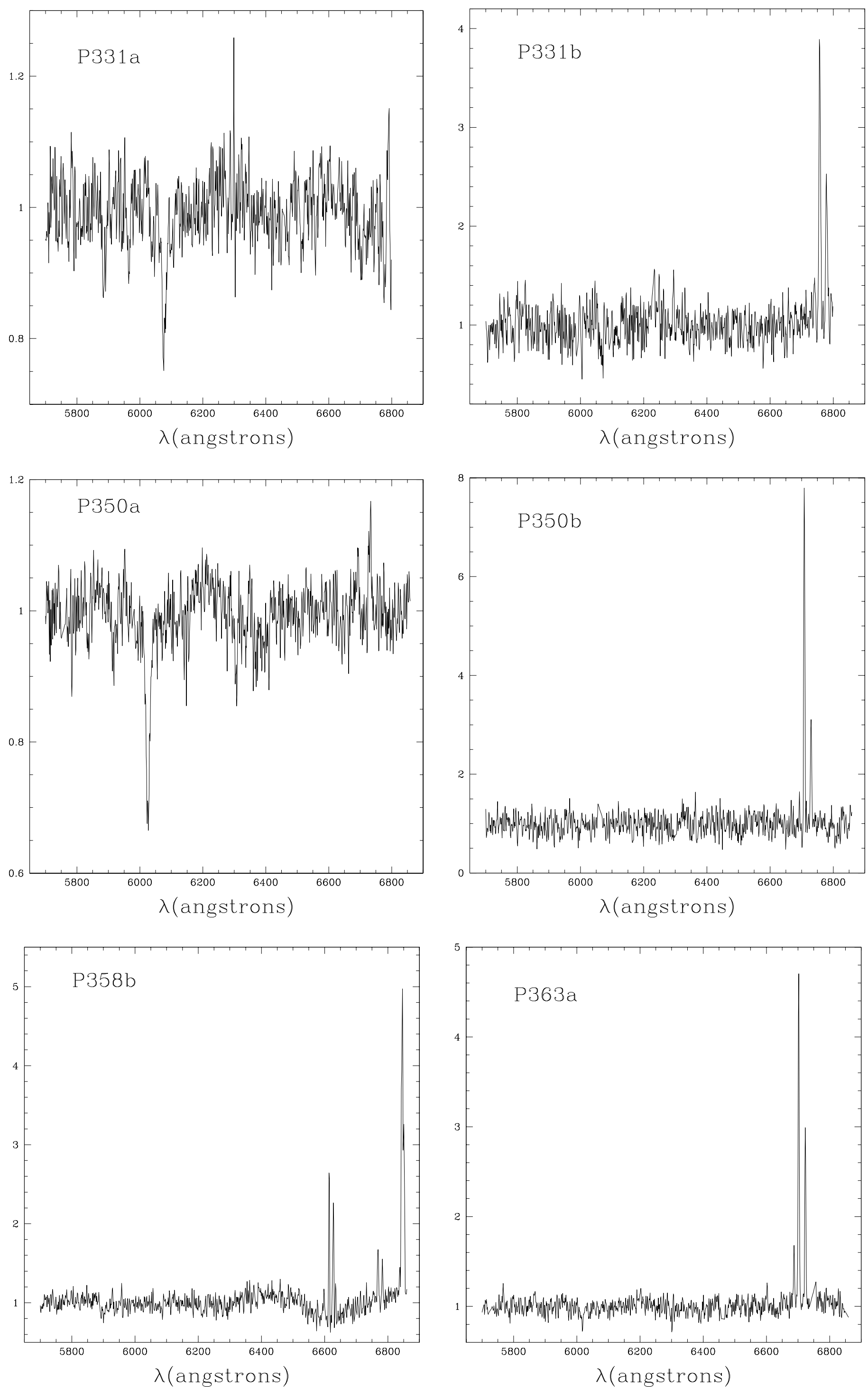


Fig. 3. continued.



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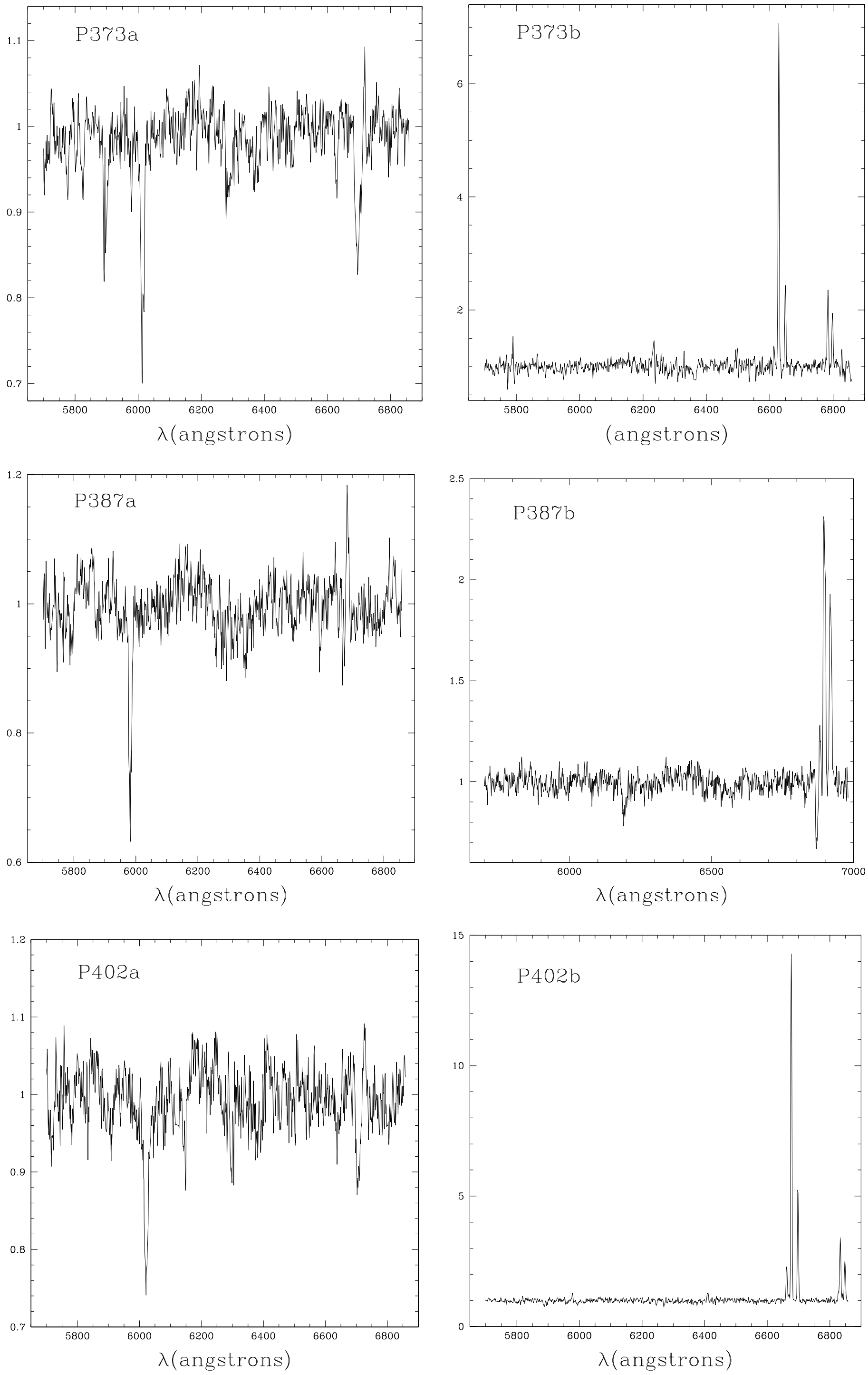

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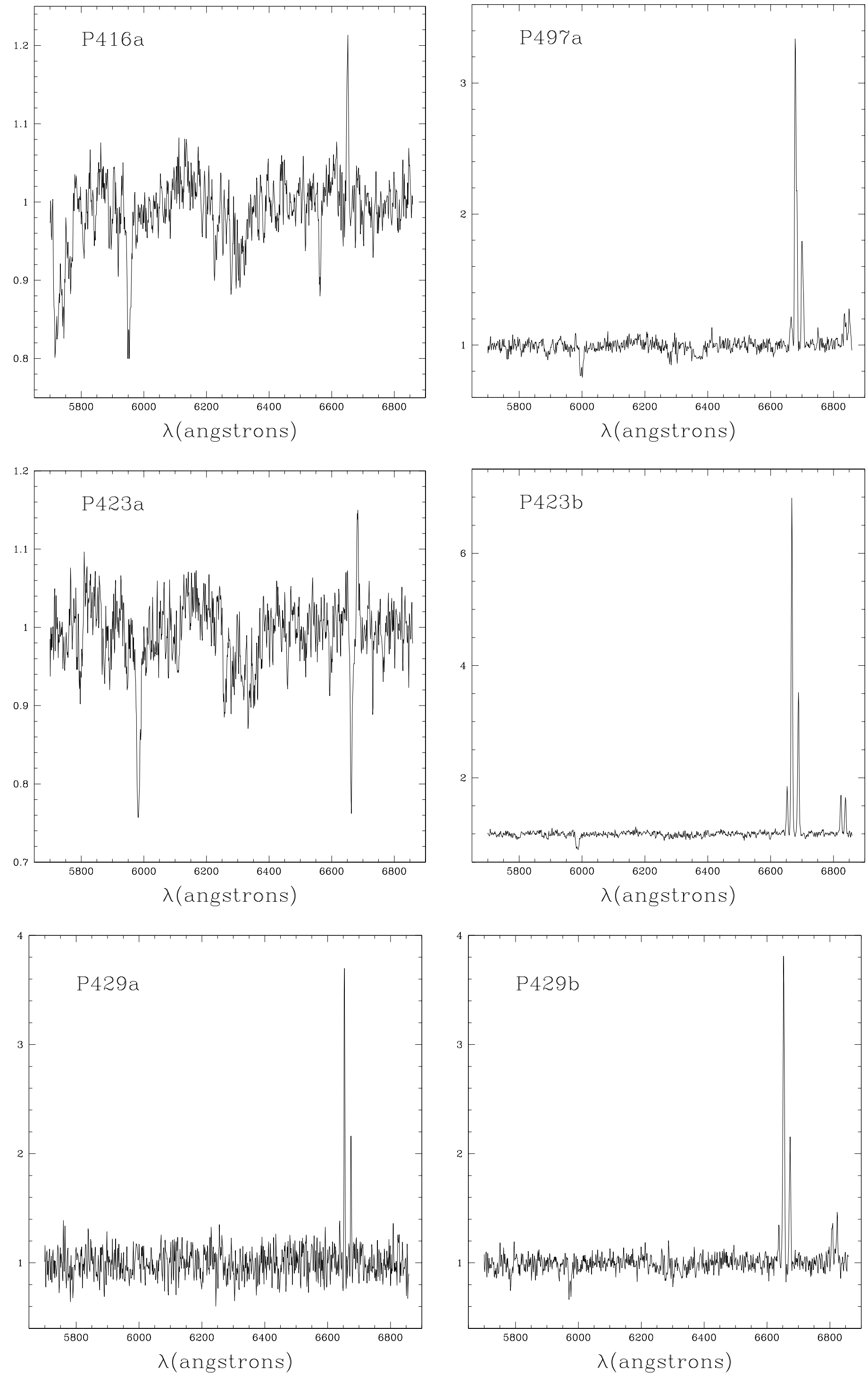

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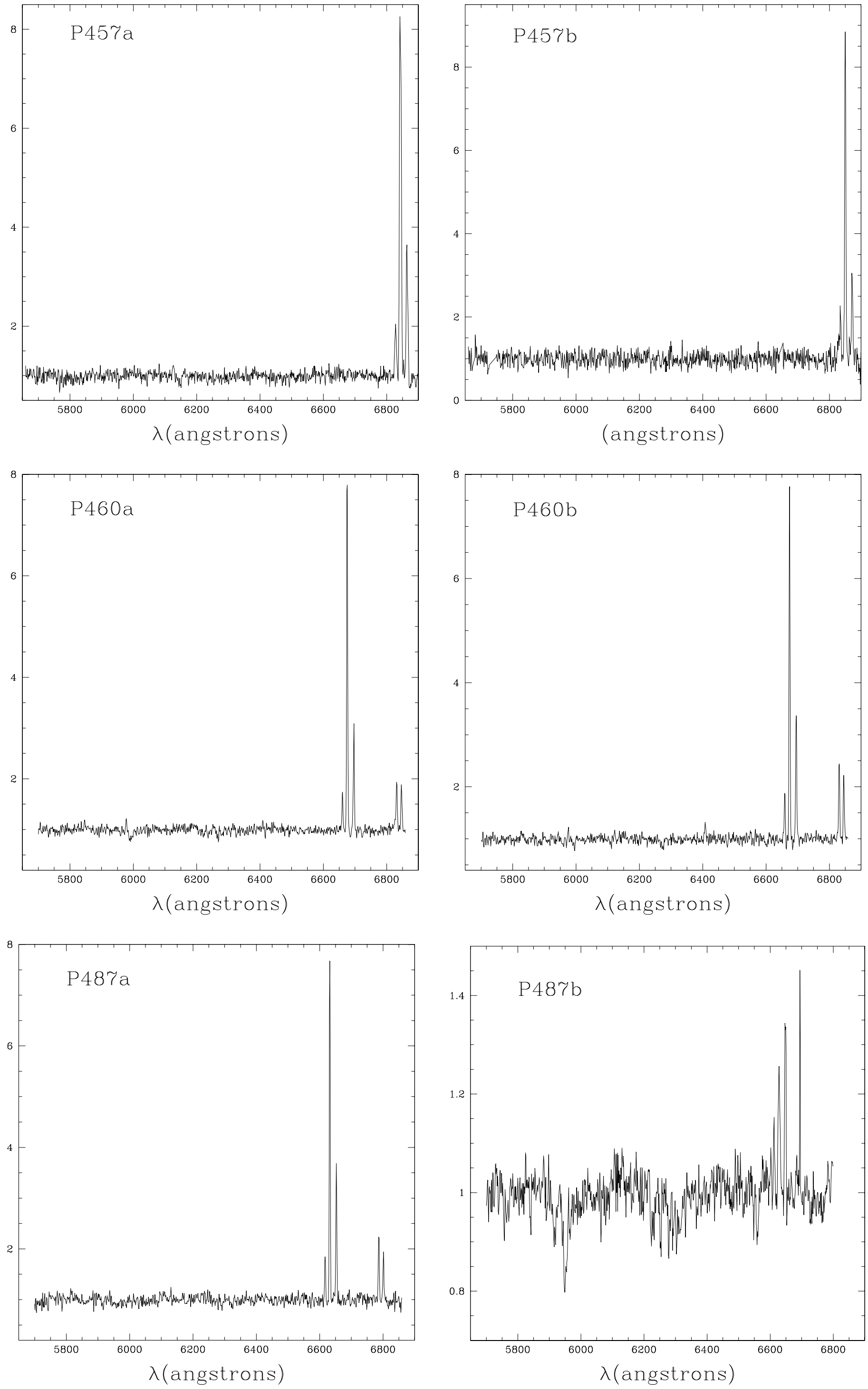

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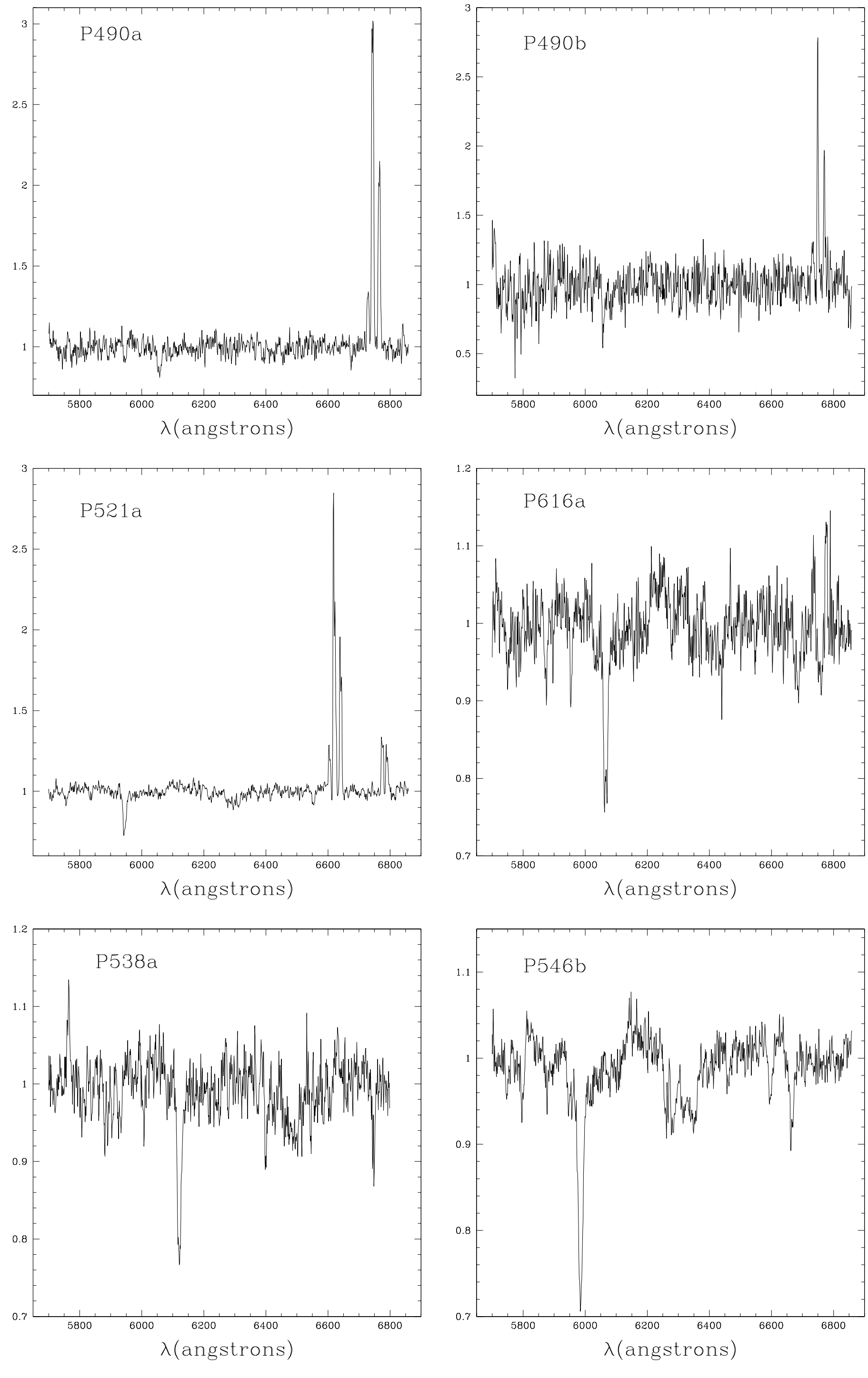

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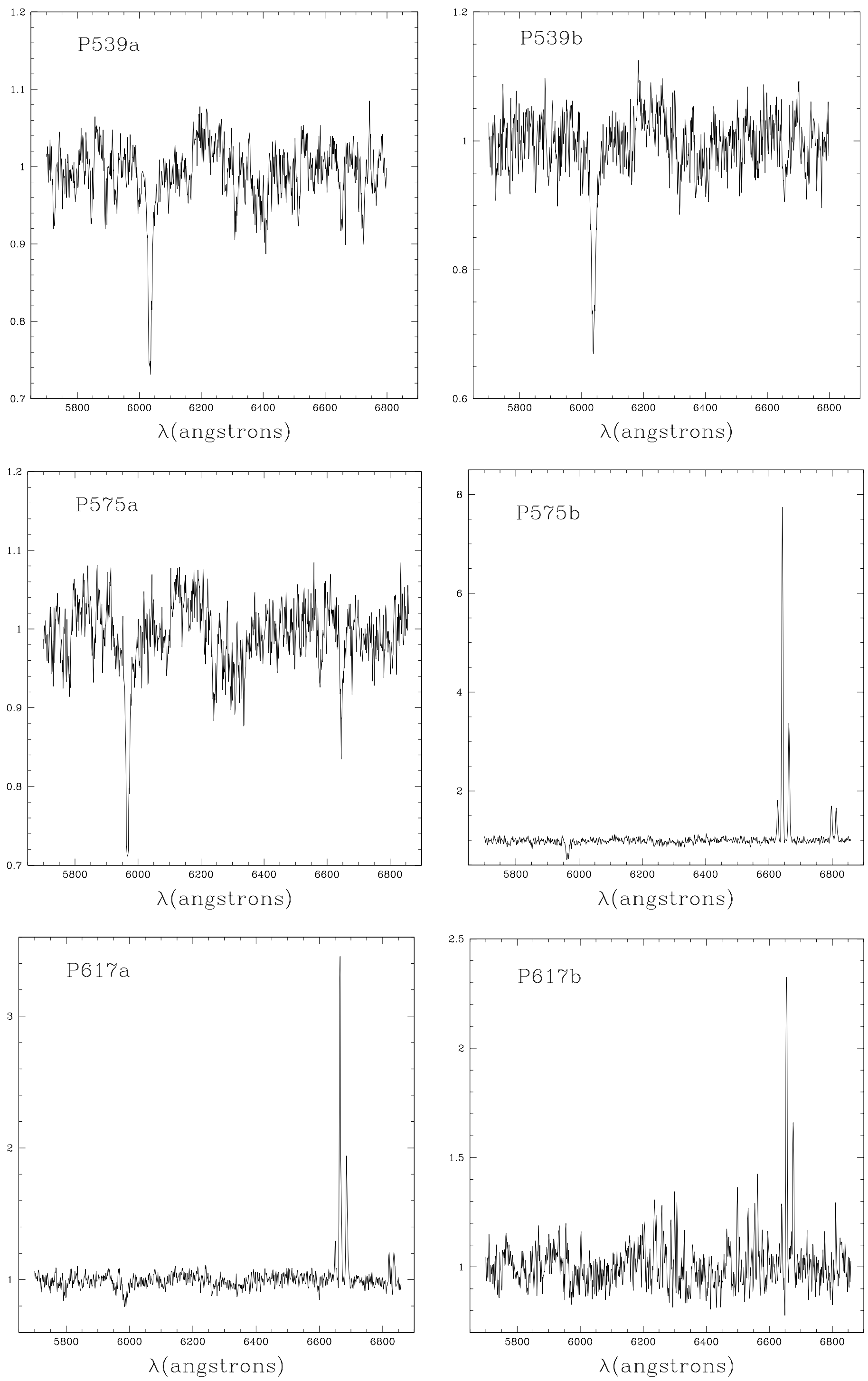

Fig. 3. continued.