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ASTRONOMY AND ASTROPHYSICS

The observational status of Stephan's Quintet*

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Abstract. We present new photometric and spectroscopic data for the galaxies in the compact group known as Stephan's Quintet. We find the strongest evidence for dynamical perturbation in the spiral component NGC 7319. Most of the damage was apparently caused by nearby NGC 7320C which passed through the group a few $\times 10^8$ years ago. NGC 7318B is a spiral galaxy that shows evidence consistent with being in the early stages of a collision with the group. NGC 7317 and 18A are either elliptical galaxies or the stripped bulges of former spiral components. They show no evidence of past or present merger activity but are embedded in a luminous halo which suggests that they are interacting with the other members of the group. The low redshift galaxy NGC 7320 is most likely a late type, dwarf spiral projected along the same line of sight as the interacting quartet.

Key words: galaxies: kinematics and dynamics; interaction – galaxies: individual: Stephan's Quintet

1. Introduction

Stephan's Quintet (SQ: also known as Arp319 and VV228) is one of the most remarkable groupings of galaxies on the sky. It was the first compact galaxy group discovered and is certainly the most intensely studied object of that class. After every new observational effort unexpected aspects have emerged, adding to the puzzling nature of such apparently dense galaxy aggregate. SQ can be regarded as a prototype of the compact group class (it is H92 in the catalog of Hickson (1982).

The puzzles connected with SQ began when its component galaxy redshifts were first measured (Burbidge & Burbidge 1961). First, one of the four higher redshift galaxies (NGC 7318B) was found to have a velocity almost 1000 km s^{-1} lower than the other three raising questions about the groups dynamical stability. Then, NGC 7320 was found to show a redshift $\sim$5700 km s^{-1} lower than the mean of the other four. SQ became one of the key objects in the debate about the nature of the redshift (Sulentic 1983).

It was suggested that NGC 7320 might be a physical companion of NGC 7331 a large, nearby Sb galaxy with similar redshift (van den Bergh 1961; Arp 1973). Possible signs of this hypothesized interaction include a tidal tail that extends from NGC 7320 towards the SE and an HI deficiency noted by Sulentic and Arp (1983). At the same time Arp (1973) interpreted the tail as a sign of interaction between NGC 7320 and the higher redshift members of SQ. The question of the distance to the different galaxies in the group was specifically addressed by Balkowski et al. (1973) and Shostak (1974) who tried to use HI data to settle the question. The results turned out to be contradictory and later observations (Allen and Sullivan 1980) showed that the HI in SQ was displaced from the optical galaxies. A summary of the many papers dealing with distances to the SQ galaxies can be found in Sulentic (1983).

This paper is concerned with the properties of the five galaxies that comprise SQ. We consider both their optical properties and the question of their normality, especially their past/present interaction state. The analysis of the properties of NGC 7318B are particularly relevant for understanding the dynamical state of SQ because they suggest that it is a recent arrival in the system (see Moles, Sulentic & Márquez 1997; MSM). The observations are presented in section 2 and analyzed galaxy-by-galaxy in section 3. The results are combined and summarized in section 4.

2. Observations and data reduction

The data were obtained at the Calar Alto (Almería, Spain) and Roque de los Muchachos (La Palma, Spain) observatories. CCD images were obtained at the prime focus of the 3.5m telescope (BVR bands, with a TEK 1024×680 CCD) and with the EOCA 1.5m telescope (BR bands, with a Thompson 1024×1024 CCD) at Calar Alto. The 3.5m telescope was also used with the Twin Spectrograph (same detector as for the images) to obtain long slit spectra of NGC 7317, NGC 7319, and through the knots

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** Visiting Astronomer, German-Spanish Astronomical Center, Calar Alto, operated by the Max-Planck-Institut fur Astronomie jointly with the Spanish National Commission for Astronomy seen North of the central pair (see Fig. 1). Long slit spectra of the other galaxies were obtained with the Intermediate Dispersion Spectrograph attached to the Cassegrain focus of the 2.5m telescope in La Palma, equipped with the IPCS. All the spectra were obtained using a slit of 1.5 arcsec width. The log of the observations is presented in Table 1.

The image were de-biased, flat-fielded and calibrated using the appropriate routines in the FIGARO package. Extinction and calibration stars were observed in order to calibrate the 3.5m telescope data. Errors in the standard stars are always smaller than 3%. We plotted the standard stars and stars in the frames in a color-color diagram in order to determine the accuracy of the calibration. The rms of the distance between the frame stars and the standards was taken as the calibration error. This turned out to be similar or less than the errors in the standard stars themselves. Total photometric parameters were determined for each galaxy. Indeed, the distortions and overlapping of the different galaxies make those determination rather uncertain and will be discussed case by case. Total magnitudes were obtained from the curve of growth and total color indices were derived. Color maps were produced to look for the presence of peculiar features. Azimuthally averaged light profiles were determined for the galaxies (see Márquez and Moles 1996, for details about the data reduction and analysis). As we will explain later, we used an elliptical model fitted to NGC 7318A to deduce its photometric parameters. Once the model was subtracted, the remaining light distribution was considered to belong to NGC 7318B.

The spectroscopic data obtained at Calar Alto has a high wavelength calibration accuracy and this data was used to derive kinematic properties. The accuracy was estimated from the position of the main sky lines in the frame. The rms values are always smaller than 0.1 Å. The La Palma data were also flux calibrated. Several standard stars were observed for this purpose. The flux errors, estimated from the comparison of the standards themselves amount to 5%. The wavelength calibration accuracy is smaller for those data, and only a limited use of them will be made for kinematic analysis.

We used cross-correlation techniques (Tonry and Davis 1979) to measure the velocity distribution of the ionized gas, and to determine the central velocity dispersion of the elliptical galaxies and of the bulges of the spiral members of the Quintet. The Mg2 strength was measured using the line and continuum spectral bands defined in Burstein et al. (1984).

3. The properties of the individual galaxies in Stephan's Quintet

The data for the different galaxies are presented separately. We begin with the brightest galaxy in the group, the low redshift member NGC 7320 and end with the pair NGC 7318A,B. An image of the SQ area is presented in Fig. 1 with galaxy identification and slit orientations indicated for spectra presented here. Positions of identified emission regions are also marked.

3.1. NGC 7320

SQ would not have satisfied the compact group selection criteria adopted by Hickson (1982) if NGC 7320 were not superimposed. In this sense, it is a compact group by accident. Without the superposed late type Sd galaxy, the remaining four members would form a quintet with fainter NGC 7320C (it does not affect the isolation of the catalogued SQ=HCG92 because it is more than three magnitudes fainter than NGC 7320). Other field galaxies are sufficiently bright and nearby that this wider quintet would not be sufficiently isolated to pass into the (Hickson 1982) compact group catalog. So the galaxies physically associated in this system form a somewhat less compact/isolated system than most Hickson groups. The core quartet is, of course, highly concentrated with a mean galaxy separation of 35 kpc. It is likely that many more groups of this kind escaped inclusion in the HCG.

We measure a redshift cz = 801 ($\pm$20)km s^{-1} for NGC 7320 that is consistent with previous values. The corrected blue magnitude, taking into account galactic and internal extinction (A_i = 0.40 and A_g = 0.35, respectively; RC3) is B_T = 12.35 (12.53 in Hickson et al. 1989). The galaxy is rather blue with (corrected) indices $(U-B)_T = -0.11$ (RC3), and $(B-V)_T = 0.46$, consistent with its late morphological type. Schombert et al. (1990) report a similar B$-$V color in their grid photometric study where N 7320 is also misidentified as one of the accordant redshift components in SQ.

No emission lines other than marginal [OII] are detected from the weak central bulge (see Fig. 3). The long slit data show no or very weak emission except in localized regions. Its distribution along the major axis of the galaxy is asymmetric (see Fig. 2a). Emission regions were only detected in the NW half of the disk. The Hα image shown in MSM indicates that this is, in part an accident of slit positioning. A more symmetric HII region distribution is found with the brightest condensations, admittedly, on the NW side. Two of these emission regions, at 19" and 35" from the center (AR5 and AR4 in Fig. 1) have redshifts (730$\pm$40 and 760$\pm$25 respectively) consistent with membership in NGC 7320. They correspond to the regions denoted A7 and A8, respectively, in Arp (1973). They show line ratios (see Fig. 2b) typical for HII regions (with a metallicity of Z $\sim 0.5 Z_{\odot}$, as frequently found for late-type spiral galaxies). The other three detected HII regions at 54", 60", and 75" from the center (AR3, AR2 and AR1 in Fig. 1) belong to the accordant quartet.

Our photometric data shows no marked internal peculiarities. As discussed in MSM, there is no clear evidence to suggest that the tail that seems to emerge from NGC 7320 actually belongs to it. The low redshift Hα image presented in that paper shows no evidence for any condensations in the tail though they are clearly seen on broad-band images. It is therefore most easily interpreted as a background feature related to interactions in the accordant redshift quartet. The fact that this tail is parallel to a second brighter one located towards the NE supports that assumption since the second tail is clearly not related to NGC 7320.

Table 1. Log of the observations

Object	Telescope	Spectral band	Exp. (s)	PA	FWHM(")	Å/pixel	Date
SQ	3.5m	Johnson B	1200	-	0.9	-	08/20/88
SQ	3.5m	Johnson V	1000	-	0.9	-	08/20/88
SQ	3.5m	Johnson R	700	-	0.9	-	08/20/88
SQ	1.5m	Johnson B	5400	-	1.2	-	10/12/92
SQ	1.5m	Gunn r	2100	-	1.2	-	10/12/92
NGC 7317	3.5m	4200Å- 5500Å	2500	109	1.1	0.9	10/31/89
NGC 7318A	2.5m	3200Å- 7000Å	3000	109	1.2	2.04	08/04/89
NGC 7318B	2.5m	3200Å- 7000Å	3600	27	1.3	2.04	08/04/89
NGC 7319	2.5m	3200Å- 7000Å	1900	142	1.2	2.04	08/04/89
NGC 7319	3.5m	6000Å- 7200Å	2000	142	1.1	1.2	08/25/89
NGC 7320	2.5m	3200Å- 7000Å	5000	134	1.5	2.04	08/02/89

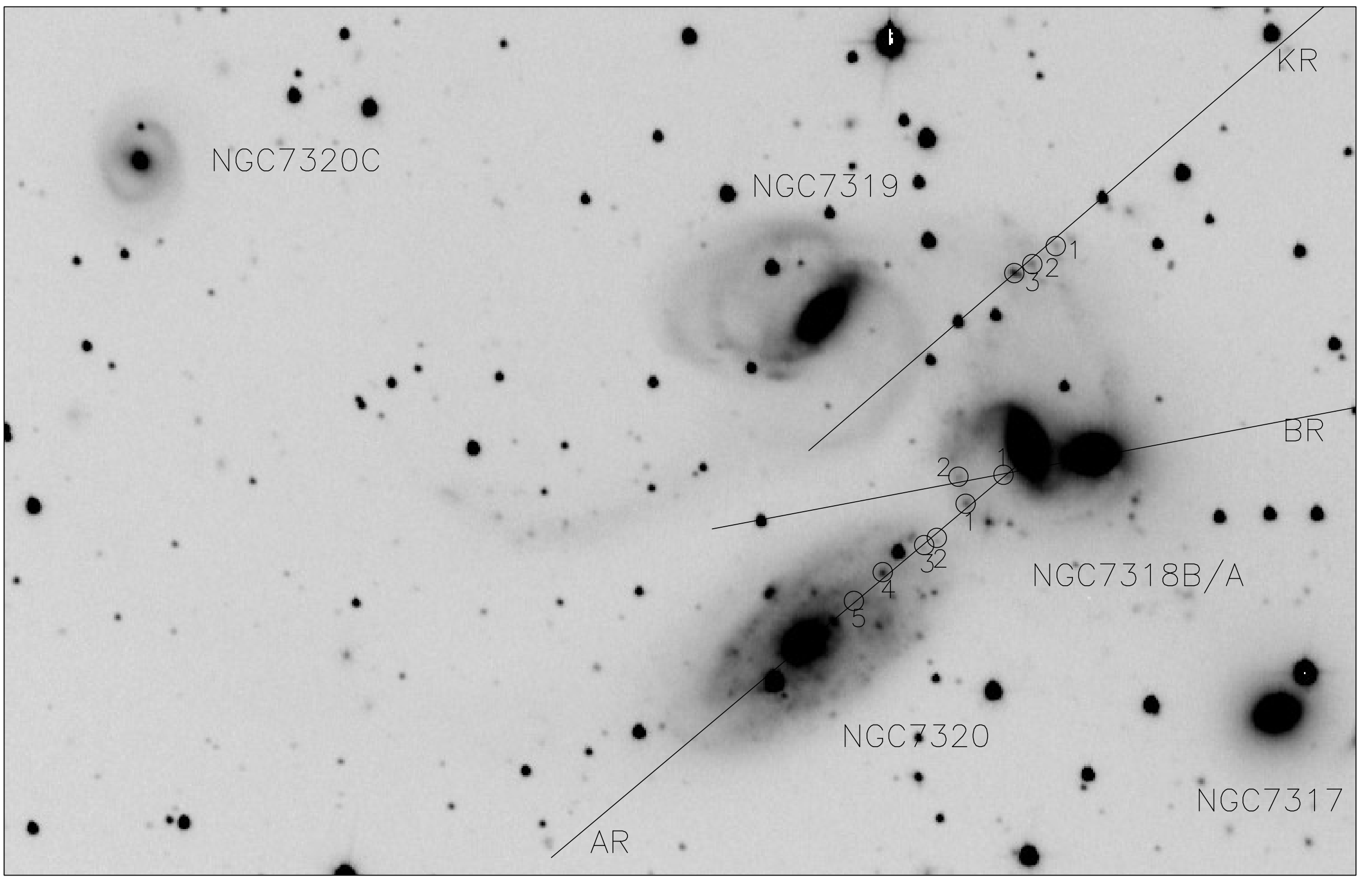

Fig. 1. R band image of the Quintet area taken with the 1.5m telescope in Calar Alto. North is at the top and East to the left. The slit positions for which detached emission knots were detected are shown. Identification is given for those knots.

The relatively undisturbed morphology of NGC 7320 suggest that it would be reasonable to apply criteria for estimating redshift independent distances. Kent (1981) applied a ΔV(21cm) vs. log L relation to NGC 7320. It was found to fall "somewhat" (meaning far) off the calibration relation in the sense that ΔV is too large for the derived optical luminosity. Shostak et al. (1984) applied a rotation amplitude vs. size relation and also found that ΔV is too large for the observed optical diameter. Bottinelli et al. (1985) report a corrected width of 160 km s^{-1} while Sulentic and Arp (1983) give a value $\Delta V \approx$ 200km s^{-1}. The latter value agrees with the Westerbork value of Shostak et al. Thus the latest determination favor a somewhat

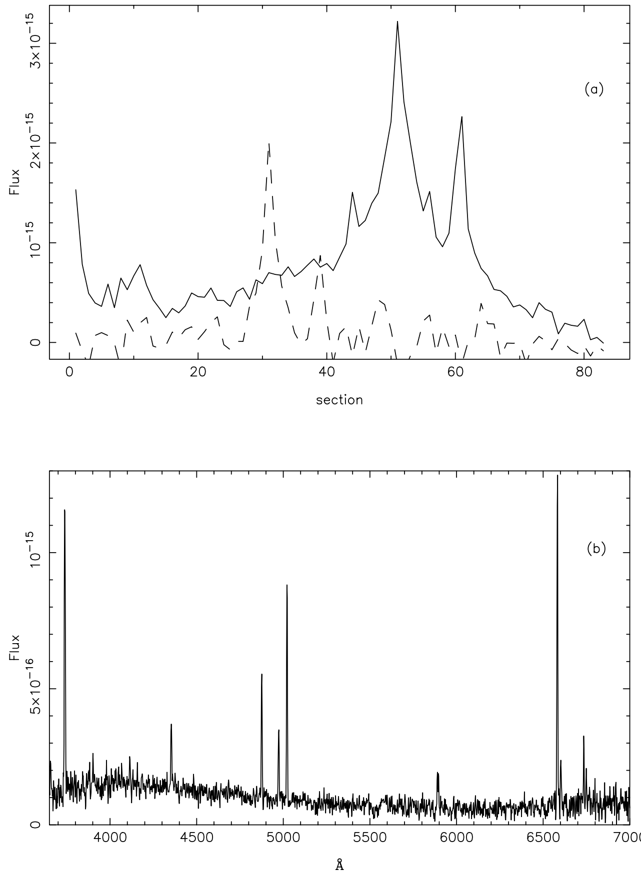

Fig. 2. a The Hα (dashed line) and continuum (solid line) flux distributions in NGC 7320 along the slit. **b** Spectrum of its brightest detected HII region (AR4).

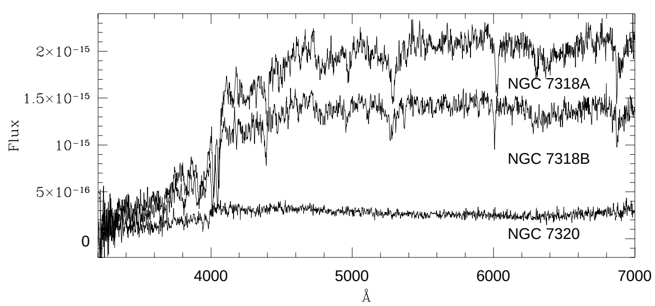

Fig. 3. The spectra of the bulges of NGC 7318A,B, and NGC 7320.

too large value for the 21cm line width. This may support the contention of Sulentic & Arp (1983) that the HI emission in NGC 7320 is peculiar and extended. Low redshift HI synthesis observations with sensitivity to extended structure could prove interesting. We have re-applied the Tully-Fisher relation using the calibration given by Pierce & Tully (1992). Good agreement is found between B_T and ΔV(21cm) consistent with a distance r$\leq$12 Mpc for NGC 7320.

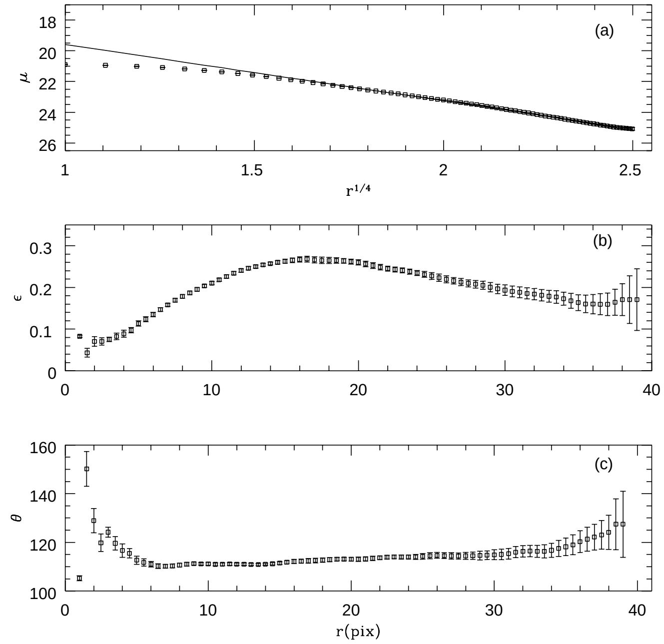

Fig. 4a–c. Photometric profiles of NGC 7317, **a** the intensity, **b** the ellipticity, and **c** the position angle.

3.2. NGC 7317

The measured parameters for NGC 7317 are presented in Table 2. The galaxy appears to be a normal E2 system. It was also classified as an elliptical by Hickson, Kindl and Auman (1989), but Hickson (1994) assigns an Sa type. The observed light distribution is affected by a nearby bright star plus (possibly) a background galaxy which can give the impression of an arc-like structure resembling a spiral arm. We derived photometric properties for this galaxy by fitting ellipses to the inner parts where the starlight has no influence and then extrapolating the model through the outer regions. The adequacy of the fitting was judged by examining the residuals of the model subtraction. Only small amplitude residuals at the noise level were observed, indicating that the fit was satisfactory. The results are presented in Fig. 4, where we plot the intensity, ellipticity and position angle profiles. They appear typical for a normal elliptical galaxy. The data are given in Table 2. The ellipticity profile shows some structure but this is not unusual especially for ellipticals belonging to groups (Bettoni & Fasano 1993). Finally the color map presented in Fig. 6a shows a smooth distribution of light for NGC 7317 without structure or well delineated components. Thus NGC 7317 shows no evidence for past or present merger activity.

From our spectrum of the central region we measure a redshift cz = 6563 ($\pm$29) km s^{-1} in good agreement with the value reported by Hickson et al. (1992). No rotation is seen along the slit at our position angle. The central velocity dispersion was measured to be σ = 215 (± 10) km s^{-1} compared to 299 km s^{-1} reported by Kent (1981). The Mg2 strength is 0.28 which is typical for early-type galaxies. From the photometric and spectroscopic data we conclude that NGC 7317 is a rea-

Table 2. Observed photometric and spectroscopic parameters.

Object	B_T	$(B-V)_T$	$(B-R)_T$	PA	i	cz	σ_c	W	Mg_2
NGC 7317	14.37	1.10	1.72	115	-	6563	215	-	0.28
NGC 7318A	14.33	0.94	1.65	105		6620	230	-	0.27
NGC 7318B	13.92			22	51	5765	220	145	0.22
NGC 7319	14.23	1.00	1.68	140		6650^a	-	200	-
NGC 7320	13.11	0.64	1.12	133	59	801	-	≤100	-

(a) This value corresponds to the systemic redshift, see text.

sonably normal elliptical galaxy. Application of the Faber and Jackson (1976) relation as revised by de Vaucouleurs and Olson (1982) gives D $\sim$ 65 Mpc, in agreement with the photometric estimate of (de Vaucouleurs and Olson (1984)).

This leaves open the question of whether NGC 7317 is an active participant in the dynamical evolution of SQ. There is no internal evidence for a past merger and no obvious evidence for interaction. The single strong form of evidence for active participation in SQ comes from the diffuse halo which clearly extends from the region of NGC 7318A,B towards NGC 7317. This halo can be seen on most deep images published over the past 25 years (Arp 1973, Arp and Kormendy 1972, Arp and Lorre 1976 and Schombert et al. 1990). Sandage and Katem (1976) suggested that much of the faint emission could be due to high latitude galactic cirrus. While this interpretation is probably true for much of the structure seen far from SQ, there is unambiguous diffuse structure associated with the group that represents evidence for dynamical evolution. We identify two components to the SQ halo: 1) a redder component that is particularly strong to the NW of NGC 7317 and 2) a bluer component associated with the tidal tails extending towards the SE. The former component clearly links NGC 7317 with the rest of the accordant galaxies.

We estimated the extent and integrated luminosity of the older halo component using IDL tasks after standard reductions and flat fielding. We removed the foreground stars which are numerous in the SQ region. We determined the boundary of the halo by smoothing the R band image with various mean and median filters. Fig. 5 shows the adopted boundary (heavy solid line) of the diffuse light chosen as the last contour level above the noise (approximate surface brightness level 25.6 mag/(")^2). Note that the halo boundary was interpolated across NGC 7320 and the blue tidal tails. The halo becomes very nonuniform north of NGC 7318AB where active star formation related to new activity is observed. In order to make a conservative estimate of the halo luminosity we chose the region between NGC 7317 and 7318A as "typical" with mean surface brightness 24.4 mag arcsec^{-2}. This average level was multiplied by the total area inside of the adopted boundary . Using our assumption of constant surface brightness we obtain M_{halo}= -20.9 $\approx L_*\approx$ the average luminosity of an SQ component.

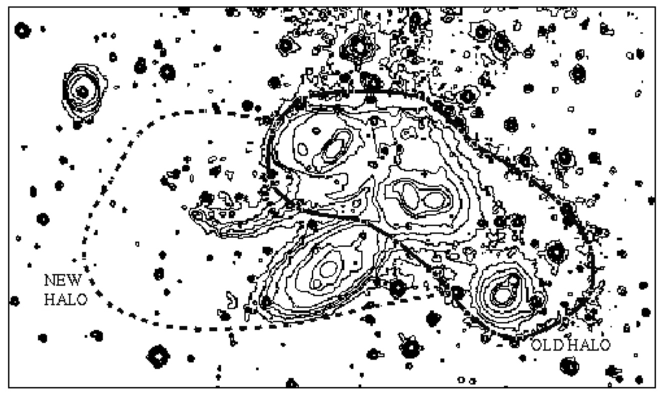

Fig. 5. Contour image of Stephan's Quintet. The solid and dashed lines represent the old and new halo, respectively (see text).

The extension and surface brightness of this diffuse light rules out the possibility that is produced by overlap of individual galaxy haloes, especially NW of NGC 7317. We note that NGC 7317 is not centered in the diffuse light that extends in its direction. This may mean that it has a considerable transverse component in motion relative to the rest of the group. This is almost required for the group to avoid collapse because the relative radial velocities of NGC 7317, 18A and 19 are very small.

3.3. NGC 7319

This SBc galaxy shows the strongest evidence for tidal disturbance. It shows a strong bar at PA = 142 which is also the position angle of the major axis. The arms show no evidence for any emission regions or dust lanes. The general aspect of the galaxy with its tails and arcs has been described in the literature (Arp and Kormendy 1972; Schombert et al. 1990). Our photometric results are given in Table 2. A blue (B$-$V= 0.57) tidal tail extends towards the SE from the edge of NGC 7319. The connection to NGC 7319 is not unambiguous as it shows no smooth connection to the spiral arms in that galaxy. The tail is parallel to and brighter than the one that passes behind NGC 7320. Both tails curve in the direction of NGC 7320C. At the same time, HI mapping (Shostak et al. 1984) shows that NGC 7319 has been completely stripped of its neutral hydrogen. Hα images (Arp 1973 and MSM) show almost no emis-

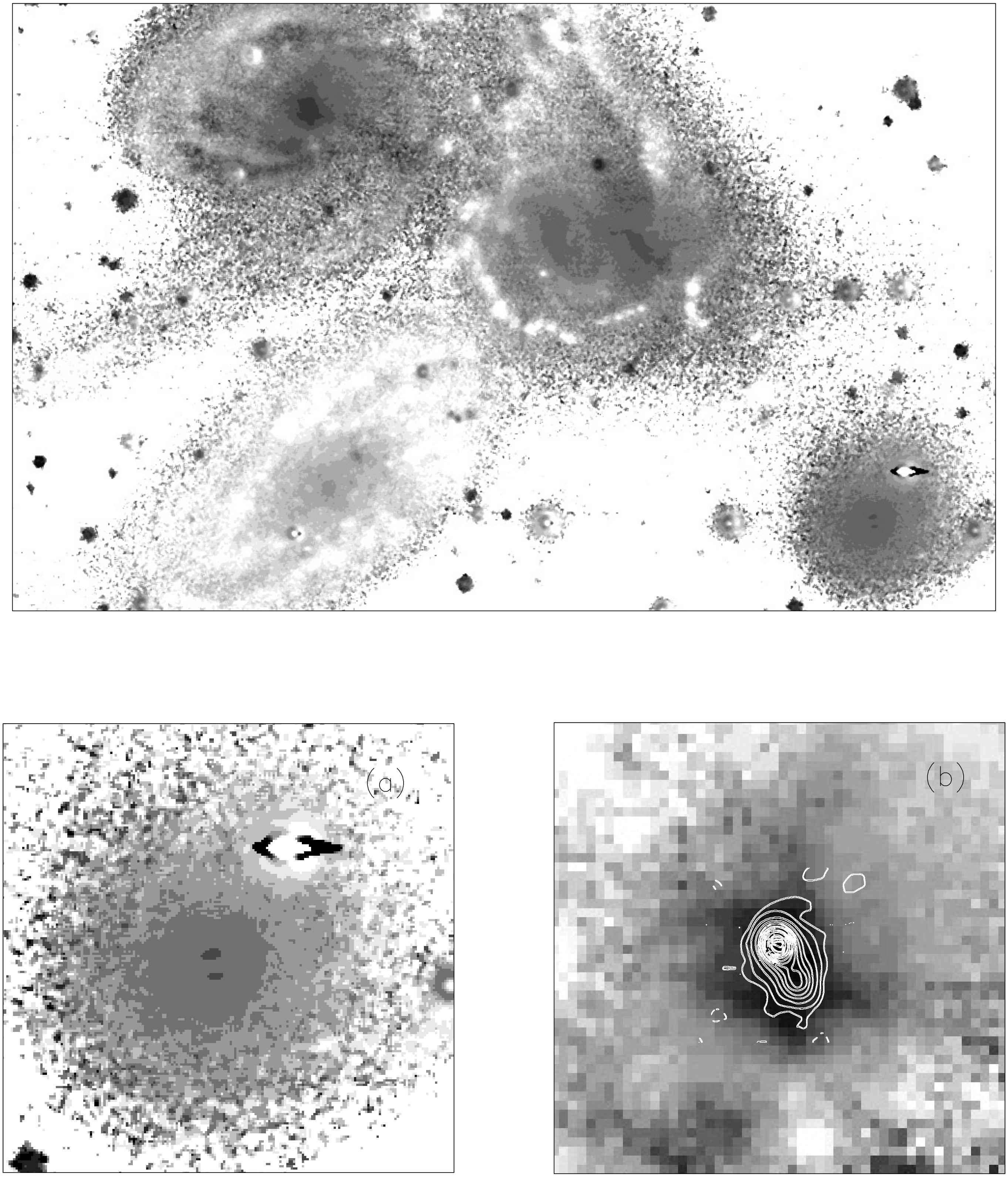

Fig. 6a–c. (B-R) color map of the galaxies in the Quintet. Darker is bluer. The two inserts show **a** NGC 7317, and **b** NGC 7319. The radio contours given in van der Hulst and Rots (1981) have been plotted on the map of the nuclear region of NGC 7319.

sion from the galaxy as well. Recent CO mapping of NGC 7319 (Yun et al. 1997) show only a few small molecular clouds that appear unrelated to the spiral structure. They match very well dust patches seen on deep optical photographs and may well represent stripped material above the disk. All those evidences support the view (Shostak et al. 1984) that NGC 7319 has suffered a strong collision/encounter that has efficiently stripped its ISM. That tail points towards NGC 7320C as the intruder responsible for the stripping event (Shostak et al. 1984; MSM)

Despite the evidence for strong dynamical evolution the galaxy retains reasonably symmetric spiral structure. It satisfies the Tully-Fisher relation when placed at its redshift distance.

NGC 7319 is a well known Seyfert 2 galaxy (see Durret 1987) with emission lines that show strong blue wings. The spectrum obtained at Calar Alto shows extended emission especially towards the NW side. The bulk of the emission however is not Hα but [NII]. Fig. 7a presents the observed $H\alpha/[NII]\lambda6583$ ratio along the slit. It can be seen that at some points only the [NII]λ6583 line was detected and, in general, the line ratio is smaller than 1. This suggests that residual gas in NGC 7319 is shocked –another manifestation of the past collision.

The kinematic data are presented in Fig. 7b. The velocity distribution is irregular (PA= 142°). The observed velocity gradient, amounting to $\sim$ 200 km s^{-1} , suggests that this may also be the kinematic major axis. The value we obtain for the redshift at the position of the active nucleus is 6770 (±25) km s^{-1} in good agreement with Hickson et al. (1992). However the kinematic center deduced from symmetrization of the central part of the observed velocity distribution, is slightly offset ($\sim$4") with respect to the active nucleus. The latter coincides with the continuum maximum while the kinematic center rests on the fainter knot shown in Fig. 6b. Therefore the systemic redshift would be V= 6650 km s^{-1} rather than the value measured for the active nucleus.

An interesting result comes from the color map shown in Fig. 6. A well delineated structure appears in the very central region, in a direction perpendicular to the bar, where the brightest (and reddest) knot coincides in position with the active nucleus. That structure is coincident with the jet-like continuum radio source reported by van der Hulst and Rots (1981) and with the extended emission-line region. The large scale outflow recently reported by Aoki et al. (1996) also extends along the same direction (see Fig. 6b). A larger and broader red feature extends from the NGC 7319 nucleus and towards the nucleus of NGC 7318B. This feature was probably detected on the high redshift Hα image shown in MSM. Arp (1973) had earlier reported detection of this structure in Hα. Perhaps we are seeing the last remnants of the shocked emission associated with the passage of NGC 7320C through SQ–that resulted in the complete stripping of HI from NGC 7319.

3.4. NGC 7318A

The overlapping light distributions of NGC 7318AB make it difficult to assign a morphological type to each galaxy. Regarding component A, it is not even a simple matter to decide whether it is an elliptical or a late type spiral. This last possibility is motivated by the presence of arm-like structures South and East of the central body that could be associated with it (see Shostak, Sullivan and Allen 1984). The type given in RC3 is .E.2.P., but it was classified as Sc by (Hickson, Kindl and Auman (1989)), and as SB0 by Hickson (1994).

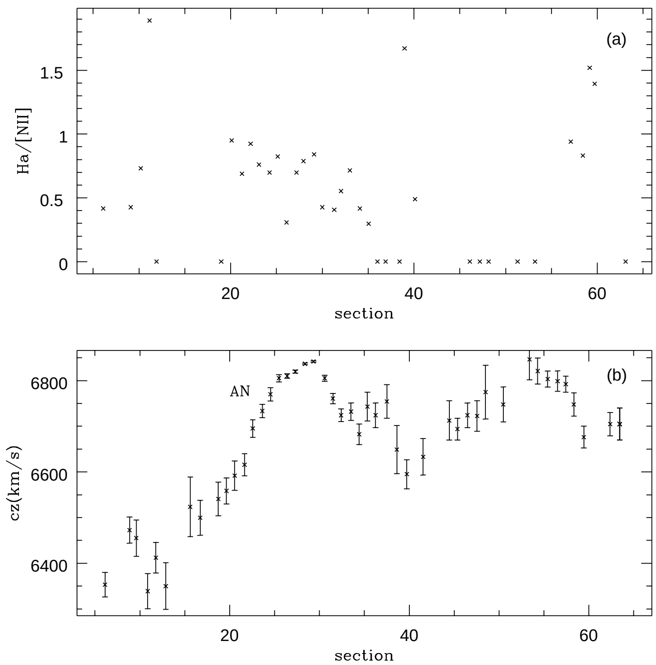

Fig. 7. a The distribution of the Hα/[NII] line ratio in NGC 7319 along the slit. **b** The velocity data along the slit. The position of the active nucleus is marked with AN

In order to help clarify the morphology of NGC 7318A we have followed the RC3 by considering the galaxy to be an elliptical, and tried to fit an elliptical light distribution to it. No objectively defined criteria were used, except that the residuals after model subtraction should reasonably attributed to the companion galaxy NGC 7318B. The main parameters, which are presented in Table 2, were measured from the fitted model. Comparison with values for NGC 7317 indicate that they are rather similar galaxies. The result of the model fit and subtraction is shown in Fig. 8. We notice that there is no sign of a bar and little evidence, if any, for a disk but there is complex residual structure. While not unprecedented in an elliptical galaxy, it could be evidence for a past interaction and/or merger event, related to the (hypothetical) earlier passage of NGC 7320C.

We measured a redshift of 6620 ($\pm$20) km s^{-1} , in excellent agreement with Hickson et al. (1992) and slightly lower than RC3. We could not detect any rotation of the stellar component at the observed PA. On the other hand, the spectroscopic results strongly reinforce the view that NGC 7318A is an early type galaxy. The central spectrum, shown in Fig. 3, is much redder than that for NGC 7318B. The Mg2 index is 0.27 mag which is very similar to the value for NGC 7317. The central velocity dispersion is σ = 230 ($\pm$ 10) km s^{-1} again lower than the value reported in Kent (1981). Application of the Faber–Jackson relation yields a most probable distance of $\sim$65 Mpc, consistent with its redshift and the value obtained by de Vaucouleurs and Olson (1984).

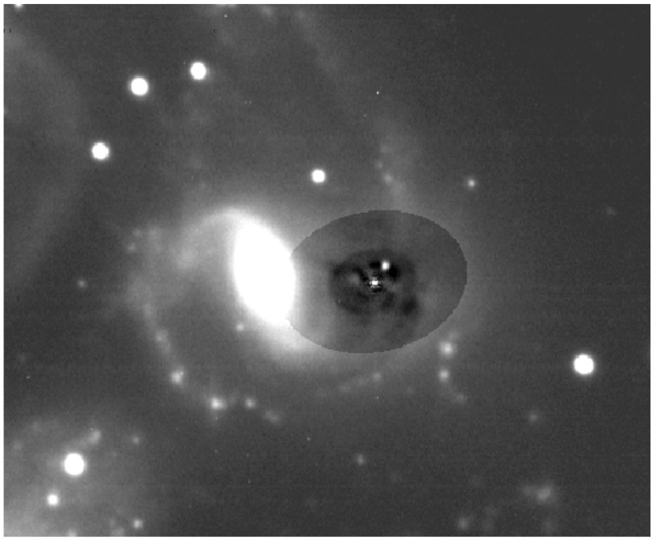

Fig. 8. B-band image of the pair NGC 7318A,B after subtraction of an elliptical fit to component A.

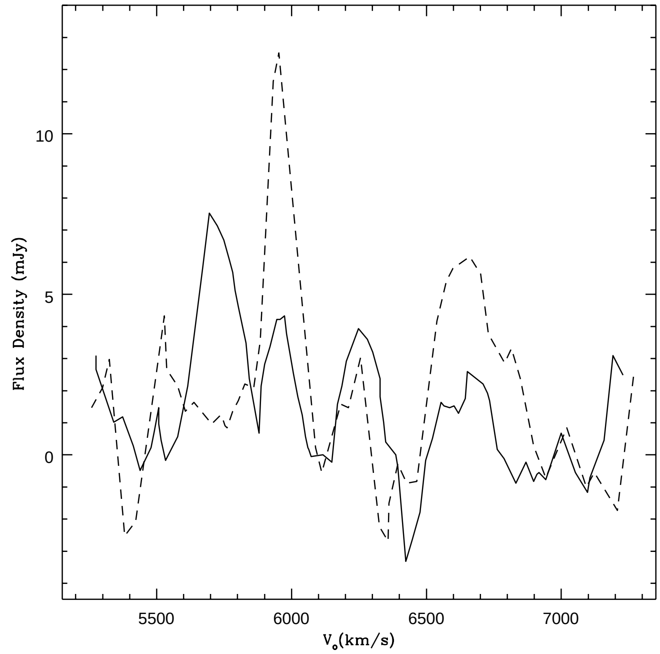

Fig. 9. Reconstruction of the HI profile of NGC 7318B from the data reported by Shostak et al. (1984).

Bushouse (1987) reported detection of modest Hα emission from the nuclear region of NGC 7318A. However, higher resolution photometry by Keel et al. (1985) reports only a more sensitive upper limits to that emission. Our long slit data show no emission. In fact, only two emission regions were detected along the slit, located 25" and 34" East of the nucleus (BR1 and BR2 in Fig. 1). They correspond to regions B7 and B8 in Arp (1973). The first belongs to NGC 7318B. Only [OII] was detected in the second region at a redshift $\sim$6300 km s^{-1} suggesting that it could be part of the ISM stripped from NGC 7319. The same comment can be made for emission region AR3 with V= 6460$\pm$40 km s^{-1} .

3.5. *NGC 7318B*

Subtraction of the elliptical model for NGC 7318A, leaves a reasonably well defined barred spiral galaxy (Fig. 8). NGC 7318B is classified SBbc in RC3. Hickson et al. (1989) assigned it an Sbc classification. The photometric parameters are given in Table 2. No emission was detected in the long slit spectrum at PA = 27 (i.e. along the bar). This is compatible with the idea that it is an old population II bulge+bar. The central velocity dispersion is 220 ($\pm$10) km s^{-1} , which is not unusual for the bulge of an early-type galaxy. The Mg2 strength amounts to 0.22 which is smaller than the values found for NGC 7317 and NGC 7318A.

Our photometric results support the idea that NGC 7318B is still relatively unperturbed as it still shows a well defined spiral pattern. Its high relative velocity (ΔV$\sim$$10^3$ km s^{-1}) and the radio/X-ray evidence for an ongoing collision on the eastern edge of this galaxy (Pietsch et al. 1997; van der Hulst and Rots 1981) strongly support the view (Shostak et al 1984) that NGC 7318B is now entering the group and for the first time. This collision is shocking the IGM of the group along with the ISM of the collider. The interface can be well seen on the high redshift Hα image shown in MSM. The idea that NGC 7318B is still a reasonably intact disk galaxy is supported by our reinterpretation of the HI data reported by Shostak et al. (1984). We suggest that the two HI clouds detected at $\sim$5700 km s^{-1} and $\sim$6000 km s^{-1} actually belong to NGC 7318B. When the HI profiles of the two clouds are superposed, the result is a double horn profile. The 2D HI distribution shows a hole in the center that is coincident with the central bulge of the galaxy as is frequently found in spiral galaxies (Fig. 9). The central redshift of the combined profile agrees with the value of 5765 ($\pm$ 30)km s^{-1} derived from the optical spectrum. The (uncorrected) amplitude of the implied rotation amounts to 145 km s^{-1} .

Our successful model subtraction of NGC 7318A suggests that all of the spiral structure in the vicinity of 7318AB can be ascribed to component B. The outer arms are somewhat chaotic and the region north of 7318B is confused at the intersection of the shock front and the northern spiral arm. Some of the detected HII regions are almost certain members of NGC 7318B, in particular the two emission regions detected on the N edge of NGC 7320 (AR1 and AR2 in Fig. 1) with V= 5540$\pm$40 and 5800$\pm$70 km s^{-1} and BR1 located 25" E from the center of NGC 7318A with V = 5850 km s^{-1} . Finally two of the detected emission knots North of the central pair (marked K1 and K2) could also be external HII regions associated with NGC 7318B. Both have the same redshift cz$\sim$ 6020 km s^{-1} , and correspond to regions B13 and B11 in Arp (1973). These velocities are consistent with our interpretation of the HI in the sense that the higher velocities are towards the north side of the galaxy.

If we accept that the atomic gas component of the NGC 7318B is still largely in place we can apply the Tully-Fisher relation to it. The value we obtain from the (corrected) observed parameters is ∼60 Mpc, similar to the values we obtained for the other high redshift members of the group.

4. Final remarks

The observational evidence suggests that the SQ galaxies preserve a well defined identity in spite of strong signs of present and past interaction. NGC 7317 and 18A show properties of elliptical galaxies. The data presented here has been used to estimate their distances through the use of the Faber & Jackson relation. The optical and HI data on NGC 7318B confirm that it is a relatively undisturbed spiral. The Tully-Fisher relation was applied to find its distance. The other two spirals in the group also satisfy the Tully-Fisher relation at their respective redshift distances.

The signs of interaction are mainly the two tidal tails on the SE side of SQ, both pointing to NGC 7320C, the diffuse light surrounding the group, and the structure seen East of NGC 7318B. The data show that NGC 7318B still has a recognizable spiral structure and an HI disk, indicating that its interaction with the other three accordant members of the group has begun only recently. A strong shock front appears to mark the interface of the collision. This is best seen in radio continuum and X-ray light but it is also visible in the high redshift Hα image shown in MSM. Some of the detached emission knots were detected in our slit spectra. We suggest that knots AR3 (cz∼6460 km s^{-1}), BR2 (cz∼ 6460 km s^{-1}) and K3 (cz∼ 6680 km s^{-1}) represented some of this new proto-halo material. The first two show very weak Hα and well detected [OII]λ3727. The region K3 corresponds to region B10 in Arp (1973). It shows a high excitation spectrum, with [OIII]λ5007/Hβ = 2.6 and [NII]λ65847/Hα = 0.11. These knots belong to a well defined structure in the intergalactic medium of the Quintet; the shock interface. The line ratios in knot K3 indicate a rather high excitation and therefore a young age. Since these ratios are fully consistent with photoionization by stars we conclude that there is some very recent star formation in the shocked zone. The gas is being shock heated and the emission regions represent material that may already be cooling at optical wavelengths.

In summary, the existing data suggest that SQ is composed of: 1) a foreground dwarf spiral galaxy (NGC 7320), 2) an interacting triplet composed of one spiral (NGC 7319) and two ellipticals (NGC 7317, 18A), and 3) a recently arrived spiral (NGC 7318B) now entering the group for the first time. The long structure seen east of the galaxy would witness this event, whereas the tidal tails support the idea that NGC 7320C probably collided with the group at least twice in the past. The detected diffuse light detected in the SQ area, constitutes an argument for the long term dynamical evolution of the group. In MSM we synthesize these observations and attempt to relate the implications of SQ to the class of compact groups.

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