Baribaud/Pelat/Phillips, Acker/Stenholm/Lundström, Alloin/Baribaud/Pelat/Phillips, Bertola/Buson/Vietri, Vettolani/Fairall/Da Costa/Chincarini, Drechsel/Andreae, Danziger/Fosbury/Lucy/Wampler, Courvoisier/Bouchet.

1.4-m CAT

October 1987: Solanki/Mathys, Holweger/Gigas/Lemke, Gratton, Spite F./Spite M.

November 1987: Spite F./Spite M., Benvenuti/Porceddu, Waelkens, Lagrange/Ferlet/Vidal-Madjar, Ferlet/Andreani/Dennefeld/Vidal-Madjar, Andreani/Ferlet/Vidal-Madjar/Grenier, Ferlet/Vidal-Madjar/Gry/Lallement, Lagrange/Ferlet/Vidal-Madjar, Barbuy/Arnould/Jorissen.

December 1987: Barbuy/Arnould/Jorissen, Grenon/Barbuy, Pottasch/Sahu, Barbuy, Pallavicini/Giampapa, Stahl/Schwarz/Wolf/Zickgraf, de Vries/van Dishoeck/Habing, Stahl/Schwarz/Wolf/Zickgraf.

January 1988: Reimers/Toussaint/Schröder, Stahl/Schwarz/Wolf/Zickgraf, Gustafsson/Edvardsson/Magain/Nissen, Gustafsson/Saar/Vilhu, Cayrel de Strobel.

February 1988: Cayrel de Strobel, Vladilo/Beckman/Crivellari/Molaro, Gillet/Pelat, Lundgren, Lenhart/Grewing/Neri.

March 1988: Lenhart/Grewing/Neri, Vreux/Magain.

1-m Photometric Telescope

October 1987: Hesselbjerg Christensen, Johansson/Bergvall, Böhnhardt/Vanysek/Beißer, Di Martino/Zappala/Cellino/Farinella, Wolf/Stahl/Davidson/Humphreys.

November 1987: Wolf/Stahl/Davidson/Humphreys, Catalano F.A./Kroll, Liller/Alcaíno, Bues/Pragal, Bues/Müller/Rupprecht, Chini/Krügel.

December 1987: Chini/Krügel, Heske/Wendker, Courvoisier/Bouchet, Busso/Silvestro/Scaltriti/Persi/Robberto, Mattila/Schnur, Barucci/Fulchignoni/Harris/Zappala/Binzel/Di Martino/Lagerkvist/Burchi/Dipaoloantonio, Lyngå/Johansson.

January 1988: Lyngå/Johansson, Courvoisier/Bouchet, Kaelble/Kappelmann/Grewing, Le Bertre/Epchtein, Reipurth/Zinnecker, Spinoglio/Persi/Coe/Ferrari-Toniolo, Westerlund/Pettersson, Balkowski/Arimoto/Boisson/Durret.

February 1988: Balkowski/Arimoto/Boisson/Durret, Thé/Westerlund/Vardya, Greenberg/Thé/Chlewicki, Courvoisier/Bouchet, Le Bertre/Epchtein, Schoembs/Barwig/Mantel, Poulain/Davoust/Nieto, Kohoutek/Martin.

March 1988: Kohoutek/Martin, Le Bertre/Epchtein, Courvoisier/Bouchet, Mermilliod/Claria, Antonello/Conconi/Mantegazza/Poretti, Moneti/Stanga.

50-cm ESO Photometric Telescope

October 1987: Group for Long Term Photometry of Variables.

November 1987: Wolf/Stahl/Davidson/Humphreys, Poretti/Antonello, Pospieszalska-Surdej/Surdej/Taylor, Cutispoto/Rodono/Ventura/Catalano F./Butler.

December 1987: Cutispoto/Rodono/Ventura/Catalano F./Butler, Mattila/Schnur.

January 1988: Debehogne/Di Martino/Zappala/De Sanctis/Lagerkvist/Magnusson, Waelkens/Cuypers.

February 1988: Waelkens/Cuypers, Thé/Westerlund/Vardya, Greenberg/Thé/Chlewicki, Kohoutek, Barrera/Mennickent/Vogt.

March 1988: Barrera/Mennickent/Vogt, Group for Long Term Photometry of Variables.

GPO 40-cm Astrograph

October 1987: Böhnhardt/Vanysek/Beißer.

November 1987: Scardia.

January 1988: Debehogne/Machado/Caldeira/Vieira/Netto/Zappala/De Sanctis/Lagerkvist/Mourao/Protitch-Benishek/Javanshir.

February 1988: Elst/Ivanova/Shkodrov/Geffert, Mermilliod/Heudier.

March 1988: Ferreri/Zappala/Di Martino/De Sanctis/Debehogne.

1.5-m Danish Telescope

October 1987: Gammelgård, Jørgensen et al., Hansen et al., Helmer et al., Lindgren/Ardeberg.

November 1987: Lindgren/Ardeberg, Griffin R.F./Griffin R.E.M./Mayor/Clube, Imbert, Imbert/Maurice/Prévot/Andersen/Nordström/Ardeberg/Lindgren/Mayor, Richtler, Leibundgut/Tammann, Noergaard-Nielsen/Hansen/Joergensen, Sauvageot/Dennefeld, Alcaíno/Liller, Jönch-Sørensen/J. Knude.

December 1987: Jönch-Sørensen/Knude, Reipurth, Jönch-Sørensen/Knude, Becker/Appenzeller/Wilson/Schulte-Ladbeck.

January 1988: Becker/Appenzeller/Wilson/Schulte-Ladbeck, Gouiffes/Cristiani, Giraud, Melnick, Della Valle/Rosino/Ortolani/Cappellaro/Turatto, Westerlund/Pettersson, v. Paradijs/v. d. Klis/Charles, Andersen/Nordström.

February 1988: Anderson/Nordström, Møller/Rasmussen, Hansen et al., Reiz et al., Andersen/Nordström/Mayor/Olsen.

March 1988: Andersen/Nordström/Mayor/Olsen, Lindgren/Ardeberg, Mayor/Duquennoy/Andersen/Nordström, Galletta/Bettoni, Ortolani/Piotto, Ortolani/Gratton.

50-cm Danish Telescope

October 1987: Olsen, Grenon/Lub.

November 1987: Grenon/Lub, Lindgren/Ardeberg.

December 1987: Lindgren/Ardeberg, Group for Long Term Photometry of Variables.

January 1988: Group for Long Term Photometry of Variables, Olsen/Gray.

February 1988: Olsen/Gray, Pellegatti Franco, Lindgren/Ardeberg, Clausen et al.

March 1988: Clausen et al., Helt/Clausen/Giménez/Vaz.

90-cm Dutch Telescope

November 1987: Grenon/Lub, v. Amerongen/v. Paradijs.

December 1987: v. Amerongen/v. Paradijs.

January 1988: de Geus/Lub/Blaauw/de Zeeuw, de Ruiter/Lub, de Loore/David/Blaauw/Hensberge/Verschueren, de Ruiter/Lub, Thé/Westerlund/Vardya.

February 1988: Thé/Westerlund/Vardya.

March 1988: Heynderickx, Caspers, Brand/Wouterloot.

IC 3370: a Box-Shaped Elliptical or S0 Galaxy?

B. JARVIS, Observatoire de Genève, Switzerland

I. Introduction

It has now been established that a significant portion ($\geq$ 1 per cent, Jarvis 1986) of disk galaxies have box- or peanut-shaped bulges. However, until fairly recently, it was generally believed that no elliptical galaxies existed which possessed these same box- or peanut-shaped characteristics. If such ellipticals do exist, then they would be interesting for several reasons. The May et al. (1985) models for box- and peanut-shaped bulges required a large amount of rotation in order to support these shapes. However, we know that most bright elliptical galaxies ($M_B \leq -21.0$) rotate slowly. Hence, a possible dichotomy may exist if bright box- or peanut-shaped "elliptical"-like (i.e. no disk) galaxies could be found which rotate as rapidly as the current models require. Such galaxies may also provide important formation, evolutionary and dynamical links between classical elliptical and disk galaxies. Fairly recently, several galaxies classified in the literature as ellipticals have indeed been found which do show strong box-like features. We report here some of the most interesting results of one of these galaxies, IC 3370.

The southern galaxy IC 3370 is classified as an E2pec in the Revised Shapley Ames Catalogue of Bright Galaxies and an E2 in the Second Reference Catalogue of Bright Galaxies.

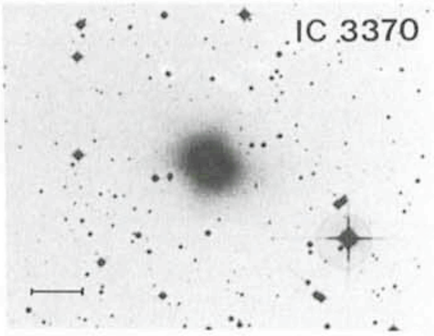

Figure 1.

The ESO/SERC J Survey (see Fig. 1) shows IC 3370 as a moderately bright elliptical galaxy with a "bow-tie" or "crossed-streamers" appearance not unlike the peanut-shaped bulge of NGC 128. On the shallower ESO B survey, IC 3370 resembles a normal elliptical galaxy.

II. Photometric Observations

The Johnson B, V and R surface photometry of IC 3370 was obtained with an RCA CCD (512 × 320 pixels) aligned E-W at the f/13 Cassegrain focus of the 0.9-m telescope at C.T.I.O. with an image scale of 0.495 arcsec pixel^{-1}. The raw data frames were reduced in the standard manner for CCD observations using the ESO MIDAS system. Figure 2 shows the isophotal contour map of IC 3370 on the Johnson B magnitude system. The V and R isophotal maps are very similar. The most important feature to note is the strong box shape of the isophotes. This shape extends over more than 3.5 magnitudes of surface brightness to the faint limit of the photometry ($\mu_B \simeq 25.0$ mag arcsec^{-2}). Moreover, Figure 2 strongly suggests that the trend of extreme "boxiness" extends to much greater distances and hence lower luminosities than can be seen within the CCD field.

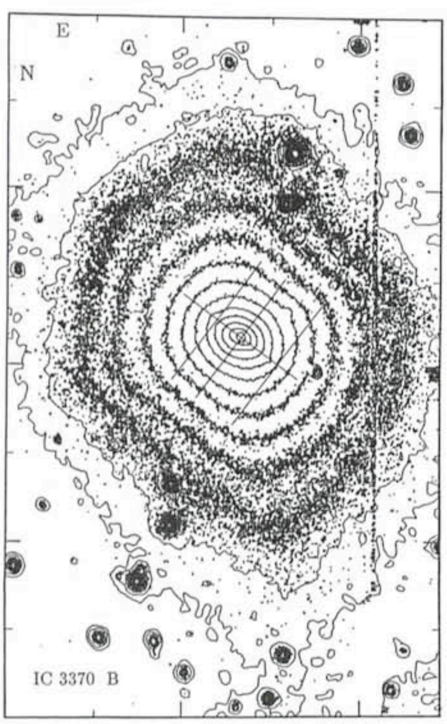

Figure 2.

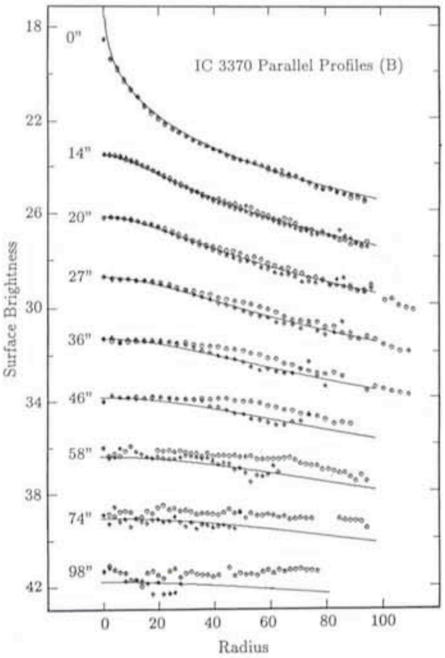

Figure 3.

Both the major and minor axis luminosity profiles in all colours are well fitted by a de Vaucouleurs $r^{\frac{1}{4}}$ law, similar to what is observed in "normal" ellipticals and the bulges of most disk galaxies. However, the minor axis luminosity profile shows a very steep decrease of luminosity with radius: $I_B \propto z^{-4.4\pm0.2}$. Most ellipticals have indices closer to that of a Hubble law ($I \propto z^{-2}$). Figure 3 shows the perpendicular luminosity profiles of IC 3370 at selected distances from the minor axis as labelled on the plot. Apart from the 0″ cut (minor axis) which closely follows an $r^{\frac{1}{4}}$ law as noted earlier, the remaining perpendicular profiles are different and are unlike both classical spheroidal bulges and normal elliptical galaxies. All show a remarkably constant luminosity for $z < 50''$, especially the 50″, 60″ and 70″ cuts before sharply decreasing, strongly indicating the box-shaped nature of the isophotes.

The total magnitude of IC 3370, uncorrected for galactic absorption is $B_T = 12.02 \pm 0.10$. Assuming a distance of 54.1 h^{-1} Mpc ($h = H_0/$50 km.s^{-1}.Mpc^{-1}) for IC 3370, the absolute B magnitude is $M_B = -22.1$. Few if any bulges are known which are significantly more luminous than IC 3370. This luminosity is more typical of elliptical galaxies.

IC 3370 also shows a significant amount of isophotal twisting amounting to a total rotation of about 25° between r = 0″ and r = 70″. This is quite puzzling in the light of our current understanding of the bulges of disk galaxies especially if the "bulge" is close to edge-on as discussed below. Classical bulges are generally believed to be nearly oblate (eg. Jarvis and Freeman, 1985) in which case no isophotal twisting should be observed at any inclination. Isophotal twisting in galaxies is most commonly interpreted as due to triaxiality. The large change of PA observed in IC 3370 is more akin to what is seen in some elliptical galaxies than in the bulges of disk galaxies. We may be forced to resort to some external process to explain this twisting such as the merger of two or more parent galaxies which simultaneously formed the box shape (see discussion below). Alternatively, we may be observing the effect of a past tidal interaction much like what NGC 205 is undergoing today.

III. Kinematic Observations

Most of the long-slit spectroscopic data for IC 3370 were obtained with the Boller and Chivens spectrograph and CCD at the ESO 3.6-m telescope. Typical exposure times for each slit position were 2 hours using a 2″ slit and a spectral resolution of about 2.4 Å. Spectra of several early K-type giant stars were also observed to form a template for measuring the galaxy velocity dispersions and rotation. The geometric stability was very good with a total shift of less than 0.2 pixels (20 km s^{-1}) over five hours of hour angle. The reduction procedures for long-slit spectroscopic data followed standard procedures and will not be discussed further here. The velocities were determined by cross-correlating the galaxy spectra with the standard star spectra. The observed velocities V and velocity dispersions σ along the various cuts in IC 3370 are shown in Figure 4. An internal consistency check on the data was made from the points where the slit positions intersected. These points, plotted as plus signs gave two independent measurements for the velocity and velocity dispersion. An external check on the instrumental setup and reduction procedures was afforded by obtaining a short exposure of the major axis of the bright galaxy NGC 4594 and comparing the observed rotation curve with that observed by Kormendy and Illingworth (1982). The results, shown in Figure 5, indicate a good agreement. It is interesting to note that the sharp turnover in the rotation curve at about 5″ on either side of the nucleus was not seen in the KI or Faber et al. (1977) data.

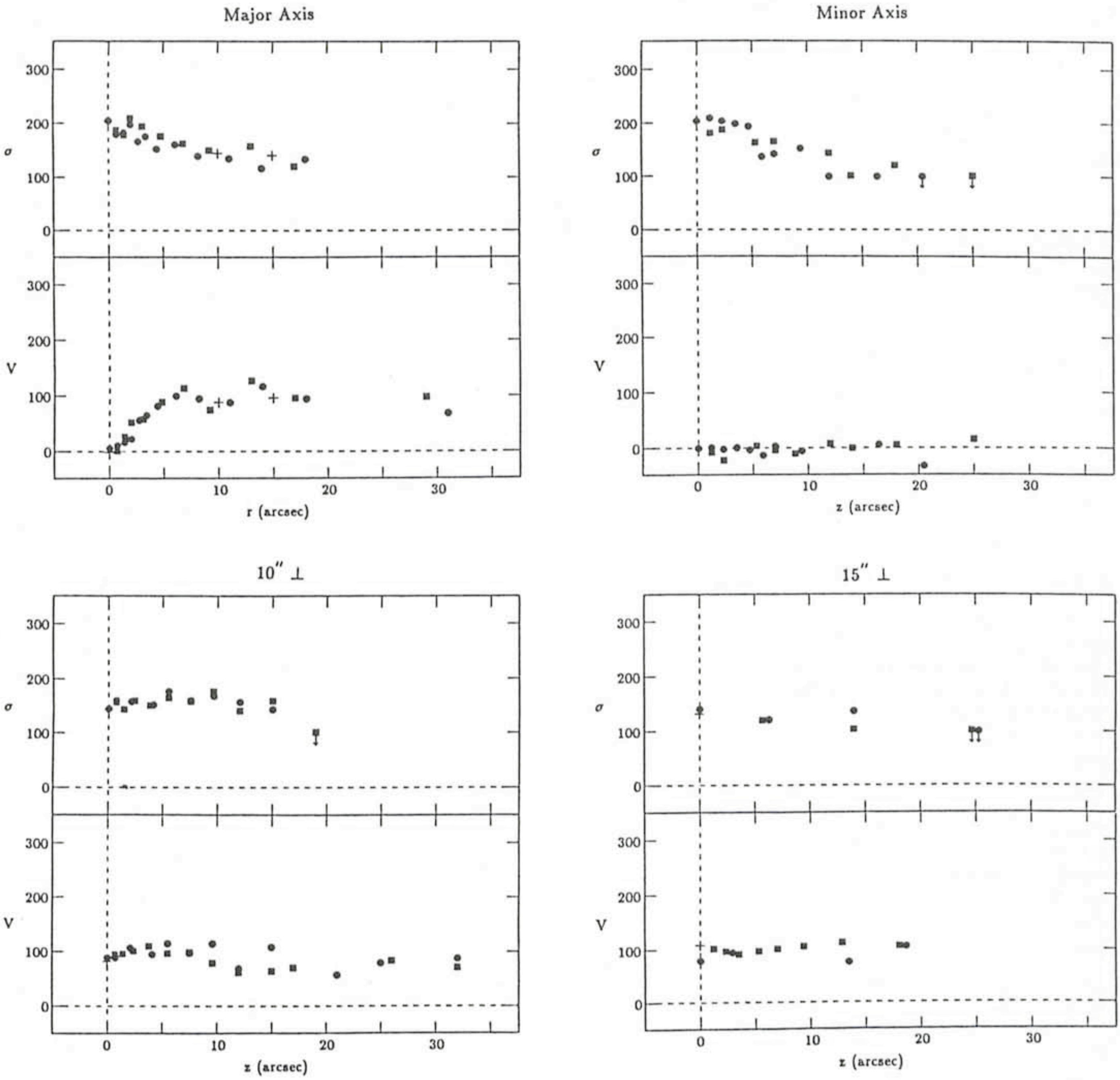

Figure 4.

Evidence for a stellar disk in IC 3370

Figure 6 shows the inner 20″ of IC 3370 divided by the same image spatially filtered with a circular Gaussian filter of FWHM = 4.9″. We can clearly see a faint luminous stellar disk totally enveloped within a much more luminous bulge. The disk is also convincingly revealed by least-squares fitting ellipses to the isophotes of the inner 20″ of IC 3370. This argues in favour of IC 3370 being an S0pec galaxy and not an E galaxy by classical definition. The large aspect ratio of the disk suggests that IC 3370 is seen very nearly edge-on. Moreover, all the Jarvis (1986) sample of 41 disk galaxies with box- or peanut-shaped bulges also had inclinations greater than about 80°. This can be no coincidence. Therefore we conclude that the presence of an observable box shape with an observable luminous high aspect ratio disk suggests an inclination for IC 3370 of $i \geq 80°$.

The observed heliocentric velocity of IC 3370 was measured to be 2959 ± 30 km s^{-1}. The inner 7″ of IC 3370 along the major axis is rotating like a solid body, reaching a maximun velocity of about 100 km s^{-1}. Beyond this point the rotation curve is quite flat. The minor axis rotation curve shows no significant mean rotation and indicates that IC 3370 is not tumbling.

The kinematically most interesting cuts are those perpendicular to the major axis and offset from the minor axis at distances of 10″ and 15″ from the nucleus. These are also shown in Figure 4. Their most striking feature is the near constancy of the velocity and dispersion with z to $z \sim r_e$ ($8h^{-1}$ kpc) for the 10″ ⊥ cut and $z \sim 0.6r_e$ ($4.8h^{-1}$ kpc) for the 15″ ⊥ cut. Therefore, *IC 3370 is strongly cylindrically rotating to large z distances above and below the plane of rotation.* In fact, it is cylindrically rotating to significantly greater z distances than have been observed before in disk galaxies with box- or peanut-shaped bulges.

IV. Implications for Formation

A natural question arises as to how these galaxies formed. What evidence is there to suggest that IC 3370 had a mostly dissipative formation much like disk galaxies or alternatively, a weak

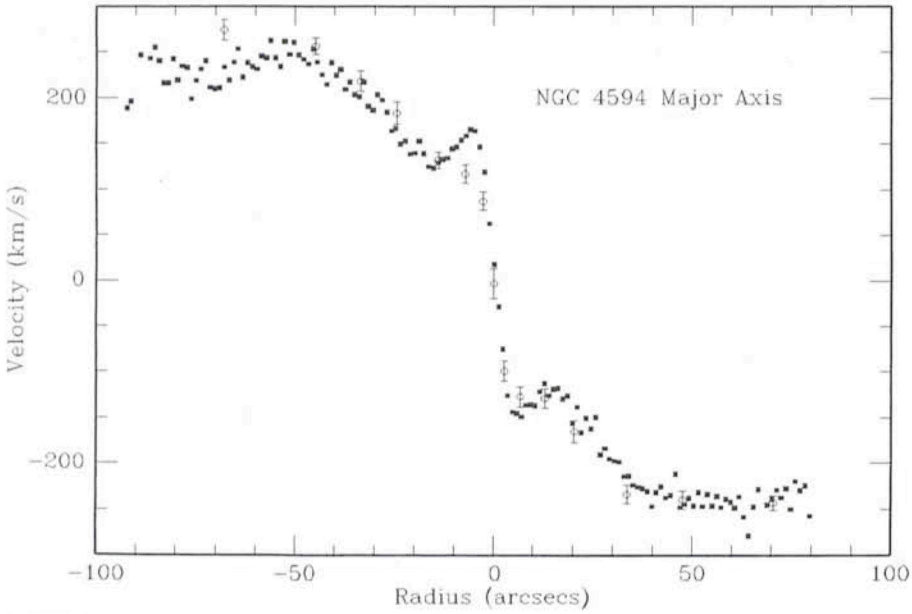

Figure 5.

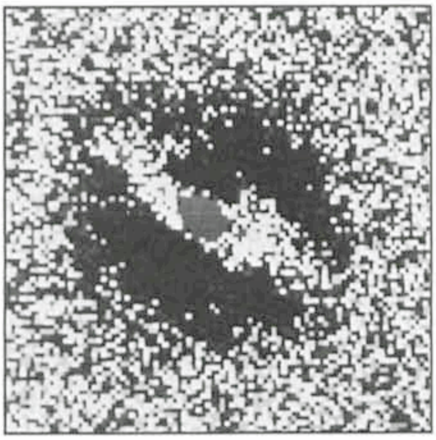

Figure 6.

dissipative history as is generally believed for the bright ellipticals? The small colour gradient in IC 3370 argues against a strongly dissipational collapse. This is also supported by the lack of a significant amount of highly dissipated material in the form of a disk. These and other more subtle points require us to look for a non-dissipative type model for IC 3370.

One alternative possibility may lie with mergers as these have been shown to be capable of producing the characteristic box and peanut shapes (Binney and Petrou, 1985). Their models showed that the slow accretion of a satellite galaxy by a more massive host can lead to the box or peanut shapes with the proviso that the mass of the bulge must not amount to more than a small fraction of the overall mass of the host system. However, for IC 3370, the ratio of the bulge mass to total mass is almost unity. Also, the satellite capture hypothesis cannot work well in the case of the host system being highly triaxial, a possibility in view of the large amount of isophotal twisting observed. Slightly triaxial or oblate elliptical galaxies with an approximately axisymmetric potential cannot be excluded however. Thus it seems that the most likely merger possibility for IC 3370 proposed by Binney and Petrou is the slow collision of two massive disk galaxies which have appropriately inclined total angular momentum vectors. The absence of a significant amount of dust in IC 3370 would tend to argue in favour that the merging progenitors were S0 galaxies unless the merger process triggered efficient star formation depleting nearly all of the gas. These proposals have no sound physical basis at present and can only be tested by adequate n-body experiments.

V. Conclusions

The main conclusions reached in this study of IC 3370 are as follows:

1. IC 3370 is an S0pec galaxy and not an elliptical as previously classified. The strongest supporting evidence for this is the discovery of a faint luminous stellar disk.
2. IC 3370 is highly cylindrically rotating to much greater z distances than have previously been observed in box- or peanut-shaped bulges.
3. The kinematic data show that IC 3370 has as much rotation as an oblate isotropic model flattened by rotation alone.
4. There is an unusually large amount of isophotal twisting in the bulge of IC 3370 amounting to a total shift of about 25°. Merger or tidal processes may offer the only satisfactory explanation for its occurrence.
5. The bulge of IC 3370 is very luminous with $M_B = -22.1$, making it one of the most luminous bulges known.

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Upgrading of the ESO 1.52-m Telescope

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A Few Words of History

At the time the ESO Convention was signed, two telescopes 1 metre in size were foreseen, one dedicated to photometric observations, the other to spectroscopic work. The latter however, was soon turned into a 1.52-metre telescope, a modified twin-brother of a telescope then under construction at the Haute-Provence Observatory. A rather large building was planned to house the coudé spectrograph and an aluminizing plant for up to 2 metre diameter mirrors, and was erected in 1968.

The 1.52-metre spectroscopic telescope was first offered to visiting astronomers for the period September 1st 1969 to March 1st 1970. The instrumentation then available consisted of the coudé spectrograph and a Cassegrain spectrograph from Marseille Observatory, aimed at radial velocity measurements. Later, an echelle spectrograph was installed at the coudé focus, working with an electronographic device and providing a resolution down to 0.015 nm. This spectrograph is present-

* Chairperson of the ESO Users Committee