episode of intense emission of electron-positron annihilation radiation (Ballet et al., 1992).

Gamma-Ray Bursts

This is a branch of X-ray astronomy where optical follow-up so far has yielded only negative or inconclusive results. The importance of finding counterparts in any waveband is however so obvious, that the search has to be continued and improved despite all disappointments in the past. The confusing situation regarding our (lack of) understanding of these enigmatic events has recently been discussed in this journal (Boer et al., 1992), so here only the main points will be mentioned: The bursts appear isotropically distributed over the sky, yet they are not homogeneously distributed in space since the number of bursts does not increase as rapidly as the volume of space accessible by instruments of different sensitivity. There are simply not enough weak bursts observed (Meegan et al., 1992). The burst durations span the range from tens of milliseconds to hundreds of seconds with a great variability of time structures and no obvious subclasses. The X-ray energy spectra are extremely hard, extending far up in the gamma-ray regime. In fact, the bursts are so deficient in soft X-rays that they cannot originate close to any stellar surface (Imamura and Epstein, 1986) – still some of the bursts exhibit lines in the X-ray spectra very reminiscent of the cyclotron resonance lines thought to be associated with strong magnetic fields surrounding neutron stars.

No model has been put forward as yet which can encompass all these apparently conflicting bits of evidence. And so far our only information channel are the X- and gamma-ray data. To progress further we must find new ways of observing emissions from the gamma-burst sources.

WATCH was one such attempt of designing an instrument which could provide positions useful for Schmidt camera follow-up with a minimal delay. But the average detection rate of gamma-bursts with WATCH has been only one per month or less, and in practice the delay between the localization of a burst by WATCH and the exposure of a Schmidt plate is typically 48 hours or more. These exposures are definitely interesting even if no object can later be found, because they set important constraints for the source models. Particularly if the bursts are assumed to originate at cosmological distances they must involve energy releases corresponding to supernova explosions and the absence of optical emission a few days after the event is disturbing. But, of course, the identification of one real counterpart would be a lot more fun than ten interesting non-detections!

Outlook for the Future

Both the WATCH instruments and the BATSE instrument will continue to provide rapid but rough gamma-burst locations for some time to come. Combining data from these instruments with those from space probes such as ULYSSES will yield more accurate positions, but with some time delay. The next improvement in the space segment may come with the launch in 1994 of HETE, a small satellite carrying conventional gamma-burst instrumentation supplemented with X-ray and UV cameras. The positions determined by HETE will be accurate to some arcminutes based on the X-ray camera and accurate to maybe 0.1 arcminute if sufficient UV emission is present to allow the UV cameras to pick up the source. The main limitation of the HETE cameras is that they cover effectively less than 10 % of the sky. But, as stated above, one good catch will be worth a lot.

On the ground, the availability of large-format CCDs for astronomical research will no doubt improve the prospects of searching for counterparts of transient X-ray sources. Such CCDs when mounted on suitable telescopes could provide a field of view matching the limited precision of the X-ray positions. The gain in sensitivity and ease of data analysis should allow much more rapid and effective searches to be performed. An alternative route, hopefully to be exploited in space astronomy, is to supplement a wide field X-ray monitor with gimballed X-ray and optical precision telescopes on the same satellite. But, with the established development times for space instrumentation, the ground observers are likely to have still another 10 years to find the elusive sources of the cosmic gamma bursts.

References

Lund, N., 1985, In: X-ray Instrumentation in Astronomy, ed. J.L. Culhane, *SPIE* **597**, p. 95.

Lund, N. and S. Brandt, 1991, IAU Circ. 5161.

Makino, F., 1991, IAU Circ. 5161.

Della Valle, M., B.J. Jarvis and R. West, 1991, IAU Circ. 5165.

Sunyaev, R., E. Jourdain and P. Laurent, 1991, IAU Circ. 5176.

Brandt, S. (editor), 1991, Proceedings of the Workshop on Nova Muscae 1991, DSRI Report 91-2. 1991.

Paciesas, W.S., M.S. Briggs, B.A. Harmon, R.B. Wilson and M.H. Finger (1992), IAU Circ. 5580.

Castro-Tirado, A.J., S. Brandt and N. Lund (1992 a), IAU Circ. 5587.

Castro-Tirado, A.J., E.P. Pavlenko, A.A. Shlyapnikov, R. Gershberg, V. Hayrapetyan, S. Brandt and N. Lund (1992 b), IAU Circ. 5588.

Castro-Tirado, A.J., S. Brandt and N. Lund (1992 c), IAU Circ. 5590.

Elvis, M., C.G. Page, K.A. Pounds, M.J. Ricketts and M.J.L. Turner (1975), *Nature*, **257**, p. 656.

Boer, M., C. Motch, H. Pedersen, S. Brandt, A.J. Castro-Tirado, N. Lund and A. Smette (1991) *The Messenger*, **66**, p. 61.

Meegan, C.A., G.J. Fishman, R.B. Wilson, W.S. Paciesas, M.N. Brock, J.M. Horack, G.N. Pendleton and C. Kouvelioutou, (1992) IAU Circ. 5641.

Imamura, J.N. and R.I. Epstein (1987), *Ap.J.* **313**, p. 711.

Looking Through the Dust – the Edge-on Galaxy NGC 7814 in the Near-Infrared

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1. Introduction

To study the photometric and morphological properties of spiral galaxies like our own, large nearby galaxies, which are assumed to be characteristic, are usually investigated in detail. To study the radial properties of galaxy disks, one looks at galaxies with a low inclination angle, while the vertical distribution of gas and stars is studied in highly inclined galaxies.

A complicating factor for the investigation of edge-on galaxies is extinction by dust in the disk. Apart from S0 galaxies, whose disks might be transparent, the disks of most edge-on galaxies are opaque in the inner regions in optical

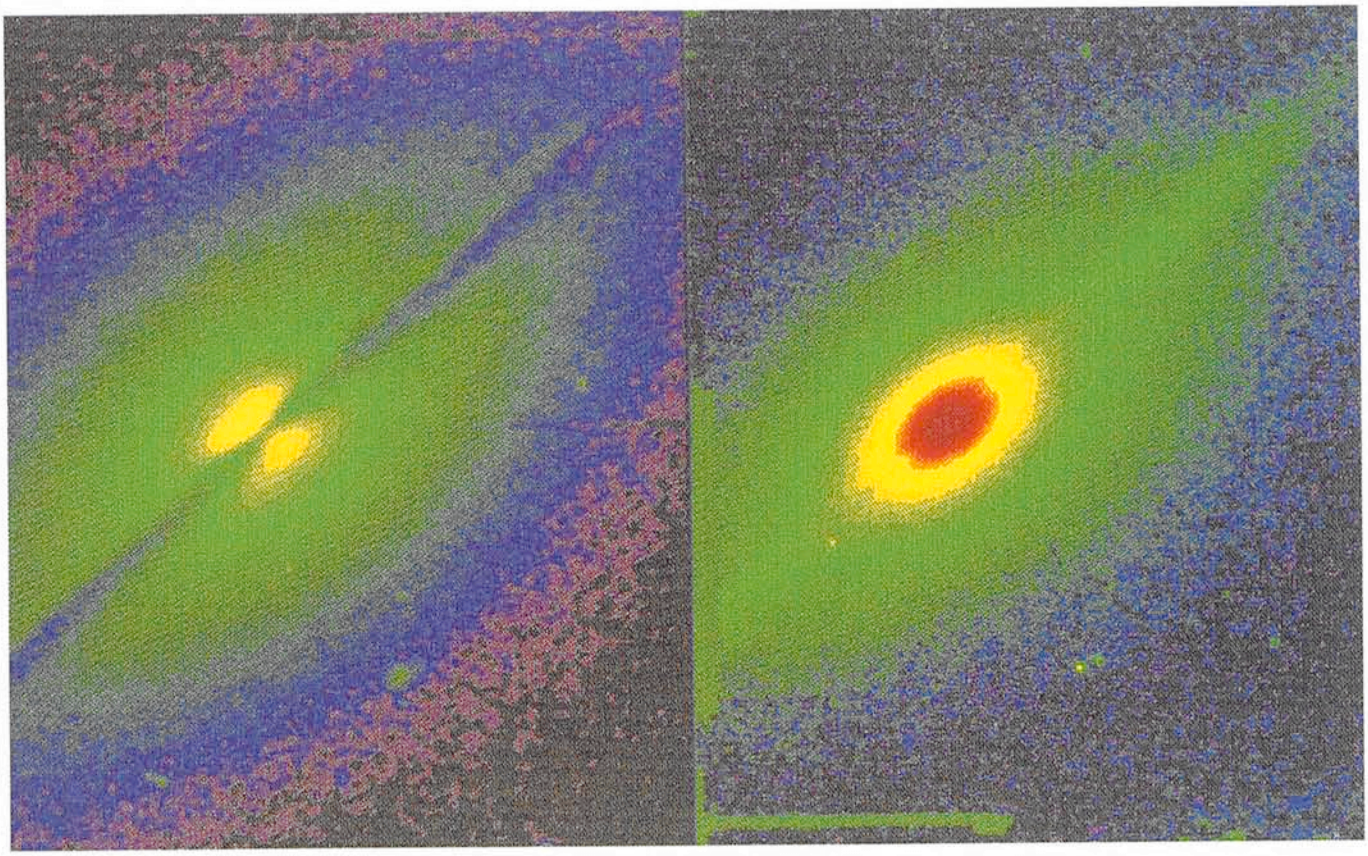

Figure 1: *Images of NGC 7814 in V (left) and K′ (right) on the same scale. The size of both fields is 100″ × 140″. N is up and E to the left. The bar at the bottom of the infrared image is caused by a bad column in the detector.*

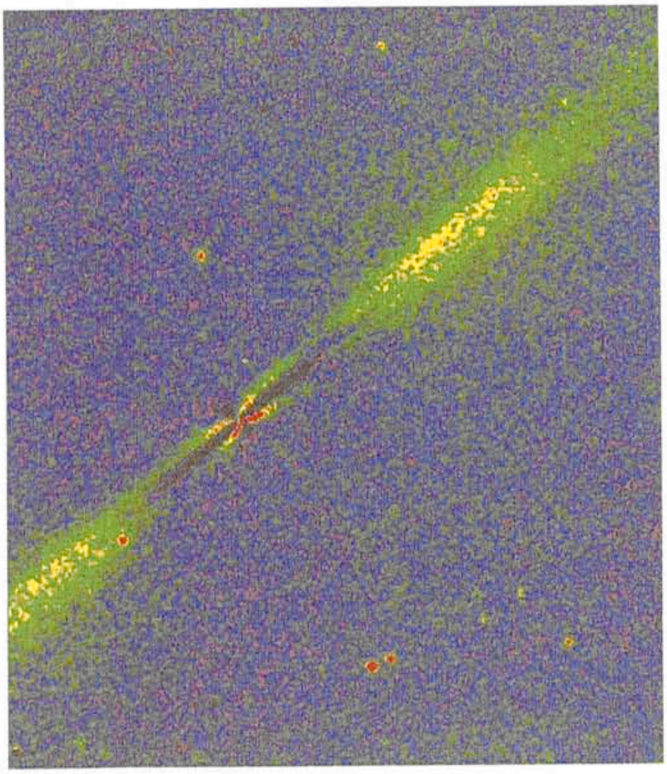

Figure 2: *K′ image of the stellar disk in NGC 7814. The field is the same as in Figure 1. This image was made by fitting ellipses outside the region of the disk, extrapolating them, and subtracting them from the galaxy. One can see that even in K′ some of the stellar light is being absorbed.*

Figure 3: *J-K′ colour map of NGC 7814. J and K′ were chosen because the seeing in those bands was the best. The field is the same as in Figure 1. Darker colours here indicate redder colours.*

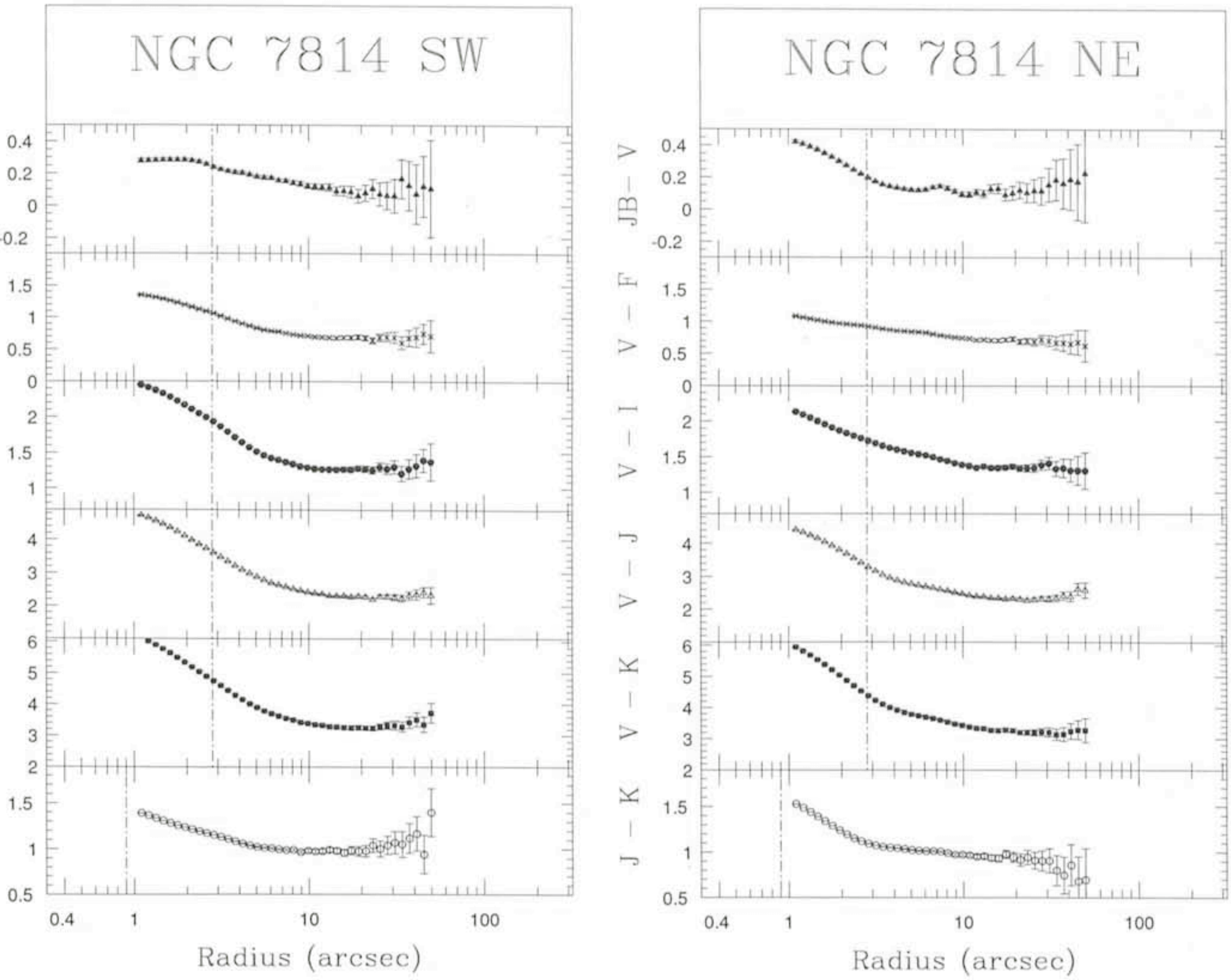

Figure 4: *Colour profiles determined in a wedge of 60° along the minor axis through the bulge. The optical colours are on the system defined by Schild and Kent (1981), where JB lies between B and V, and F is more or less equal to Cousins R. Note the large gradients towards the centre and the constancy of the colour outside 10″.*

bands like B and V. This makes the determination of the z-distribution of the stars, as well as the light distribution of the bulge, very difficult. Although for edge-on galaxies it is easy to separate bulge and disk, it is difficult to know how much extinction is present in front of the bulge.

One of the great advantages of going to the near-infrared (NIR) is that the extinction by dust is much smaller (e.g. Schultz and Wiemer 1975). In the K-band at 2.2 μm, $A_K/A_V \approx 0.11$ in our Galaxy (Rieke and Lebofsky, 1985), and this ratio for large external spirals is likely to be similar (Knapen et al., 1991). So by observing an edge-on spiral in the NIR, we can study the properties of the stars of both bulge and disk much better.

For a few months ESO has an instrument-telescope combination that offers the large field of view and the good sampling in the NIR that is needed for the study of large nearby spirals, namely IRAC2 on the 2.2-m (Moorwood et al., 1992). We have used this combination to study the Sa galaxy NGC 7814, a system with a large bulge and a disk that is very close to edge-on. This galaxy has been investigated before by Van der Kruit and Searle (1982), who found large colour variations as a function of radius in the bulge, which they interpreted as metallicity gradients. This result, as well as the aperture photometry of Wirth and Shaw (1983) was taken as evidence that metallicity gradients in bulges are common.

2. Observational Details

NGC 7814 was observed in September 1992 in the J (1.2 μm) and K′ (2.1 μm) filters. Because of the good seeing (0.9″) we chose to observe it in two magnifications, namely LC (0.49″/pixel) and LB (0.27″/pixel). During this run a best seeing of 0.70″ (FWHM) was reached. The galaxy was observed in 4 different positions on the array in each band and magnification, interleaved with 4 exposures of the sky background. This was done to get rid of bad pixels and to be able to cancel out sensitivity variations across the chip. We thus obtained better flatfields than by using only the calibration exposures on the dome. The reduction and analysis was done in Garching, where the IR data were also compared with optical CCD frames taken by R. Schild at the F. L. Whipple Observatory in Arizona. In Figure 1 we show the images in K′ and V both on the same scale. The dust lane is much more clearly visible in V, but the resolution in K′ is much higher.

3. Properties of the Disk

To separate bulge and disk in K′ we first removed the region of the disk outside the central area ($r \geq 20''$ and $|z| \leq 10''$), fitting ellipses as a function of radius in the remaining area, and extrapolating and subtracting the contribution of those ellipses in the region of the disk (see Fig. 2). This method leaves

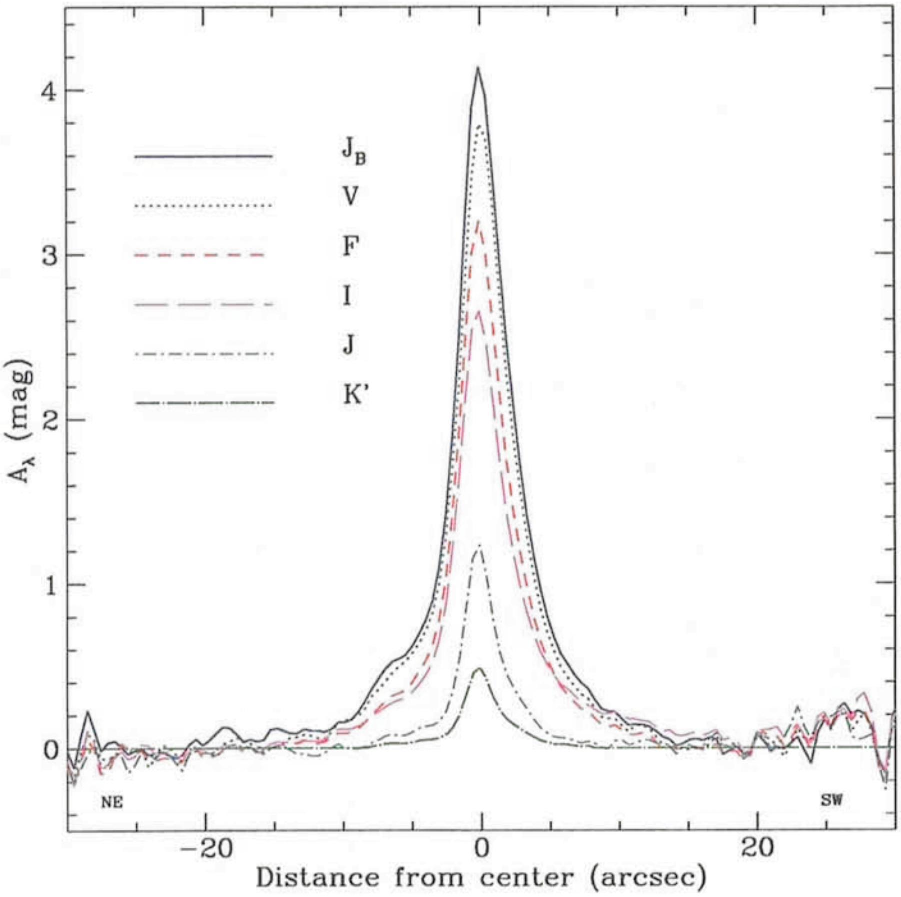

Figure 5: *Profiles of the extinction along the minor axis, calculated in a band with a width of 1.5″. The same colours are used here as in Figure 4.*

a "hole" in the disk in the centre, which is probably unrealistic, but the fact that our isophotes here are boxy (e.g. Carter, 1979) shows that the contribution of the disk at any radius is less than 0.5% of that of the bulge.

One sees a sharp absorption band, which also makes the disk in the outer regions asymmetric. It shows that extinction, although insignificant, is still present in K′. We measured the thickness (FWHM) of the disk at several positions and find values between 7 and 10″, with an average of 9″, which would correspond to 480 pc if this galaxy were at 12 Mpc, a distance obtained from the Tully-Fisher relation (Aaronson et al., 1980). Exponential fits also give an average scale height of 9 ± 1″. Our galaxy has a scale height of ≈ 200 pc (Kent et al., 1991), which implies that the disk of NGC 7814 is thicker, or that the disk is inclined. Assuming a diameter of 8′, as obtained from the HI (Van der Kruit and Searle, 1982) the disk cannot be inclined by more than 1°.

The dust lane itself is thinner than the disk. In the J – K′ colour map, shown in Figure 3, the thin absorption band is seen across the whole disk. The FWHM of the dustlane varies between 3.1″ and 4.6″, more than a factor 2 smaller than the thickness of the disk. This can be understood if the dustlane, as in our Galaxy, is associated with the young stars, which have a much smaller vertical scale height. For NGC 7814 we find that the thickness of the dust distribution lies between 0.33 and 0.5 times the thickness of the distribution of old stars producing the K′ light. For spiral galaxies one would expect such a ratio from the relation between surface brightness and inclination (see Peletier and Willner, 1992).

4. Properties of the Bulge

The fact that NGC 7814 is relatively nearby and has a large bulge makes it, just like the Sombrero, a prime candidate for the study of stellar population gradients in bulges. It is in general not possible to determine from colours alone whether gradients are caused by extinction by dust or by metallicity variations. Secondary, morphological arguments can however sometimes be used; usually one can detect dust because it shows a patchy distribution. For NGC 7814 it is clear that the reddening in the disk is caused by extinction. It is clear from the colour map (Fig. 3) that the colour variations outside the disk are much smaller. We have determined the colour profiles in a number of optical and NIR colours in a wedge along the minor axis with an opening angle of 60°, and plotted them in Figure 4.

Large colour gradients are seen within 10″ from the centre, but at larger radii the colours are constant. Extinction by dust, also because the colour profiles on the NE and SW side are not symmetric. Some minor metallicity change within 10″ can however not be excluded. In a recent survey Balcells and Peletier (1992) find that the stellar population gradients in bulges are similar to those in ellipticals of the same luminosity. NGC 7814 agrees with this, because its bulge luminosity is M_B = −19.1 (at 12 Mpc), and elliptical galaxies of that luminosity usually do not display any metallicity gradient. If this result for bulges turns out to be general, it shows that the mechanism that formed the disk has not perturbed the bulge in general, implying that it happened later, and gradually.

We have calculated extinction profiles along the minor axis. Since the centre of the galaxy is obscured by the dust lane, we cannot simply subtract the obscured half of the disk from the unobscured half, as in the case of the Sombrero galaxy (Knapen et al., 1991). Here, we have estimated the unobscured profile from the profile in K′, using the J – K′ profile and the galactic extinction law (which is probably valid, see Knapen et al., 1991). The results are presented in Figure 5. Note the asymmetry in the dust profiles, well visible in images of NGC 7814 (see Fig. 1). The maximum edge-on extinction in the K′ band is 0.2 magnitude, in the B band it is some 4 mag. The bump in the profiles between 5″ and 10″ from the centre toward the NE may be caused by inhomogeneities, or alternatively by warping in the dust lane.

We can see from this example that with the new IRAC2 data it is now possible to perform a good decomposition of bulge and disk in spiral galaxies, and to determine some fundamental properties of both components due to the much reduced influence of dust extinction in the NIR bands.

References

Aaronson, M., Mould, J. R. and Huchra, J. P., 1980, *ApJ*, **237**, 655.

Balcells, M. and Peletier, R. F., 1992, in IAU Symposium 153, *Galactic Bulges*, Gent, 17-21 August 1992.

Carter, D., 1979, *MNRAS*, **186**, 897.

Kent, S. M., Dame, T. M. and Fazio, G. G., 1991, *ApJ*, **378**, 131.

Knapen, J. H., Hes, R., Beckman, J. E. and Peletier, R. F., 1991, *AA*, **241**, 42.

Moorwood, A., Finger, G., Biereichel, P., Delabre, B., Van Dijsseldonk, A., Huster, G., Lizon, J.-L., Meyer, M., Gemperlein, H. and Moneti, A., 1992, *The Messenger*, **69**, 61.
Peletier, R. F. and Willner, S. P., 1992, *AJ*, **103**, 1761.
Rieke, G. H. and Lebofsky, M. J., 1985, *ApJ*, **288**, 618.
Schild, R. and Kent, S. M., 1981, *Proc. SPIE*, **290**, 186.
Schultz, G. V. and Wiemer, W., 1975, *AA*, **43**, 133.
Van der Kruit, P. C. and Searle, L., 1982, *AA*, **110**, 79.
Wirth, A. and Shaw, R., 1983, *AJ*, **88**, 171.

Dark Matter in CL0017 (z = 0.272)

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1. Introduction

The motion of galaxies has been used to study the gravitational field around cluster cores and, thus, estimate their masses. An independent way to obtain the total mass in clusters is now available using gravitational lensing. In fact, gravitational arcs have become an additional test to probe not only the existence and amount of dark matter in clusters but also how this matter is distributed. (For a review see Tyson 1992).

Using recent results from observations of a medium-redshift rich cluster of galaxies, namely CL0017, we here make the case for one of the best candidates where to look for gravitational arcs. From spectroscopic data from 5 clusters at $z \sim 0.3$, we find that CL0017 meets all the necessary characteristics for a gravitational arc search: high mass, high M/L, medium redshift and extreme compactness.

2. Discussion

CL0017, a rich cluster at a redshift of 0.272, has turned out to be quite an interesting case. It was first discovered on deep CFHT prime focus plates by Infante et al. (1986). It is located near the South Galactic Pole and contains a giant galaxy at its centre, probably a cD galaxy. This galaxy is surrounded by several smaller galaxies in a disk-like configuration, all embedded in what seems to be a common, extremely compact, halo of diameter $\sim 77h^{-1}$ kpc ($q_0 = 0$) and total absolute magnitude in V of −24.

The brightest members of this cluster are clearly very red (i.e. (B−V) = 0.9) as would be expected for a cluster dominated by E/S0 galaxies. However, a significant blue population of galaxies (with (B−V) < 0.7, which would correspond to later than Sab spirals) is also found, consistent with the findings of Butcher and Oemler (1984) of a higher fraction of blue to red galaxies in medium redshift clusters as compared to low z clusters.

The above results motivated more detailed photometric and spectroscopic observations of this cluster. In 1987 Quintana and Infante observed the central nucleus of this cluster with the 2.5-m Las Campanas Observatory 2DF spectrograph and obtained a velocity of 81435 ± 68 km/sec (z = 0.272). Later in 1991, Giraud acquired short B,V and R CCD exposures with EMMI on the NTT. As reported in Infante, Giraud and Triay (1991), an arc-like feature on all these deep images was confirmed. Although during the NTT observations the seeing was 0.9″, poor for NTT standards, the arc-like feature is quite conspicuous in all the frames. The arc is significantly bluer than the red cluster galaxies. Furthermore, images of the cluster have been obtained in a variety of bandpasses (V,R,I,g,r) on a number of telescopes (CTIO 4-m, ESO 2.2-m, LCO 1-m). A paper reporting the results is in preparation (Infante et al. 1992).

Here we report the results from our spectroscopic observations with EFOSC1 on the ESO 3.6-m telescope. The observations were carried out on three non photometric nights in December 1990. Two multiobject plates were used to obtain spectra of about 25 selected red galaxies. The aim was to determine a dynamical mass of the cluster, particularly of its core, and its mass-to-light ratio. The spectra were reduced twice; a preliminary reduction with IHAP software and then a final reduction using IRAF 2D spectral package (details in Infante et al. 1992). Both reductions gave consistent results.

In Figure 1 we show the distribution of velocities. After clipping out 3 sigma

VELOCITY HISTOGRAM CL0017

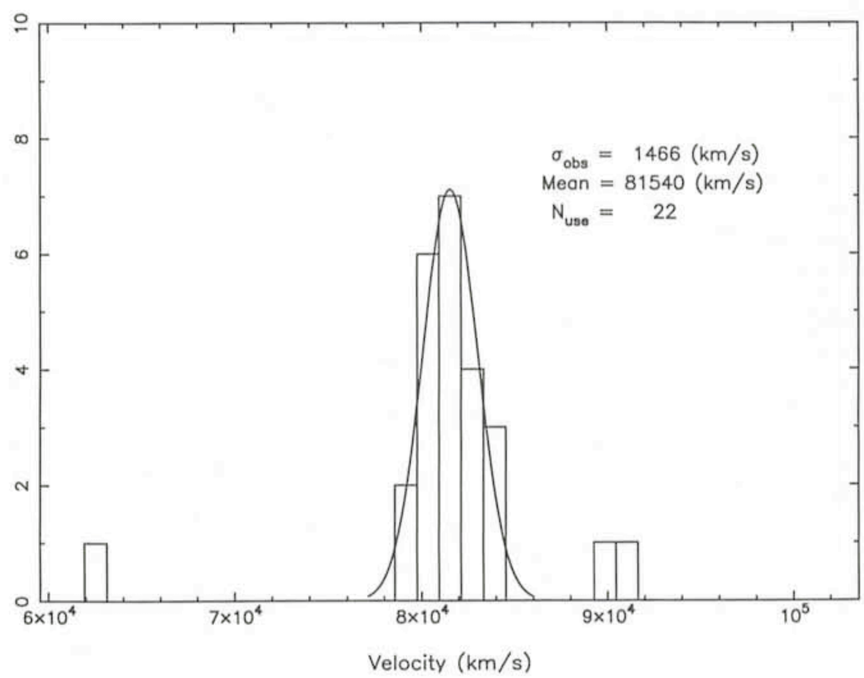

Figure 1: *Histogram of velocities in CL0017. Galaxies with velocities larger than 3σ have been removed.* 22 out of 26 galaxies remained. We also plot the best gaussian distribution to the points.