analysis of these data will be presented elsewhere (Bardelli et al., in preparation). On a qualitative basis, we can here conclude that Figures 1 and 3 suggest that the massive cluster A3558 could be accreting galaxies from its nearby clusters; probably, this is the beginning of a merging process. Further redshift data about these clusters will enable us to calculate the masses of A3558 and A3562, in order to estimate the time scale of this merging.

### 4. Future Work

A3558 is the richest ACO cluster (the only one with richness class 4) and is placed in the core of the SSC; moreover, it is probably attracting its surrounding clusters. For this reason it is important to determine its mass and its dynamical state. For this purpose, we have observed it in the X-ray wavelength with the ROSAT satellite: Figure 4 is the image of this cluster obtained with the PSPC camera, in the range 0.1–2.4 KeV, with an exposure time of ~ 30,000 seconds. Similar observations for the cluster A3528 (the central cluster of the concentration A3528-A3530-A3532, see Zucca et al., 1993) are scheduled for the next ROSAT observing period.

In the context of further optical observations, our next run at the 3.6-m ESO telescope will be in February 1993. In this run we will extend the coverage of the core of the SSC and we will observe the A3528-A3530-A3532 structure, in addition to the observation of the field #1 (A3562). These data will allow an estimate of the mass of these clusters.

In order to study the mass distribution of the whole complex and to estimate the overdensity of galaxies outside clusters, we are also planning to map the whole SSC with a regular grid of MEFOS fields, observing all galaxies with $17 < b_J < 18$.

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## HIGH-RESOLUTION IMAGING WITH THE NTT:

# The Starburst Galaxy NGC 1808


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### 1. Introduction

NGC 1808 is a beautiful spiral galaxy located in the southern sky at a distance of more than 10 Mpc. The peculiarity of its nuclear region has first been mentioned by Morgan (1958) who identified numerous, extremely brilliant, small nuclei in the central region which he called "hot spots". A real-colour image of this most interesting and unusual central region has been presented in *The Messenger* by Véron-Cetty & Véron (1983). This image nicely demonstrates the presence of several very blue "hot spots", corresponding to bright H II regions, and of a reddish nucleus which shows spectroscopic evidence for the presence of Seyfert activity (Véron-Cetty & Véron 1985).

An additional peculiarity of this complex central region was noted in 1968 by Burbidge & Burbidge. They found that NGC 1808 "contains an unusual amount of dust [in the disk] and some curious dust lanes which look almost radial in form". These prominent dust filaments which seem to emerge from the nuclear region are best seen on optical short exposures of NGC 1808, e.g., those given by Laustsen et al. (1987) or Tarenghi (1990) in a previous issue of *The Messenger*. Whereas in 1970 Arp & Bertola already speculated "that these lanes represent the passage of compact bodies outwards from the nucleus", we now have observational evidence that they are indeed connected with the outflow of neutral and ionized gas into the halo of NGC 1808 (Koribalski et al. 1992a, Phillips 1992). Also new is the discovery of a fast rotating torus of cold gas very near to the centre which has been revealed using HI absorption measurements against the extended radio continuum emission (Koribalski et al. 1992b).

The far-infrared (FIR) luminosity of NGC 1808 is with $\approx 2\ 10^{10}\ L_\odot$ quite high, similar to NGC 253 and M 82.

Here, we want to present high-resolution Hα observations of NGC 1808 which have been kindly made available by Sandro D'Odorico from ESO (thanks a lot!). These new data may very well help answering the question how the various phenomena observed in NGC 1808 are related to each other.

### 2. Observations

Over the last couple of years the starburst galaxy NGC 1808 has been observed in detail with the Very Large

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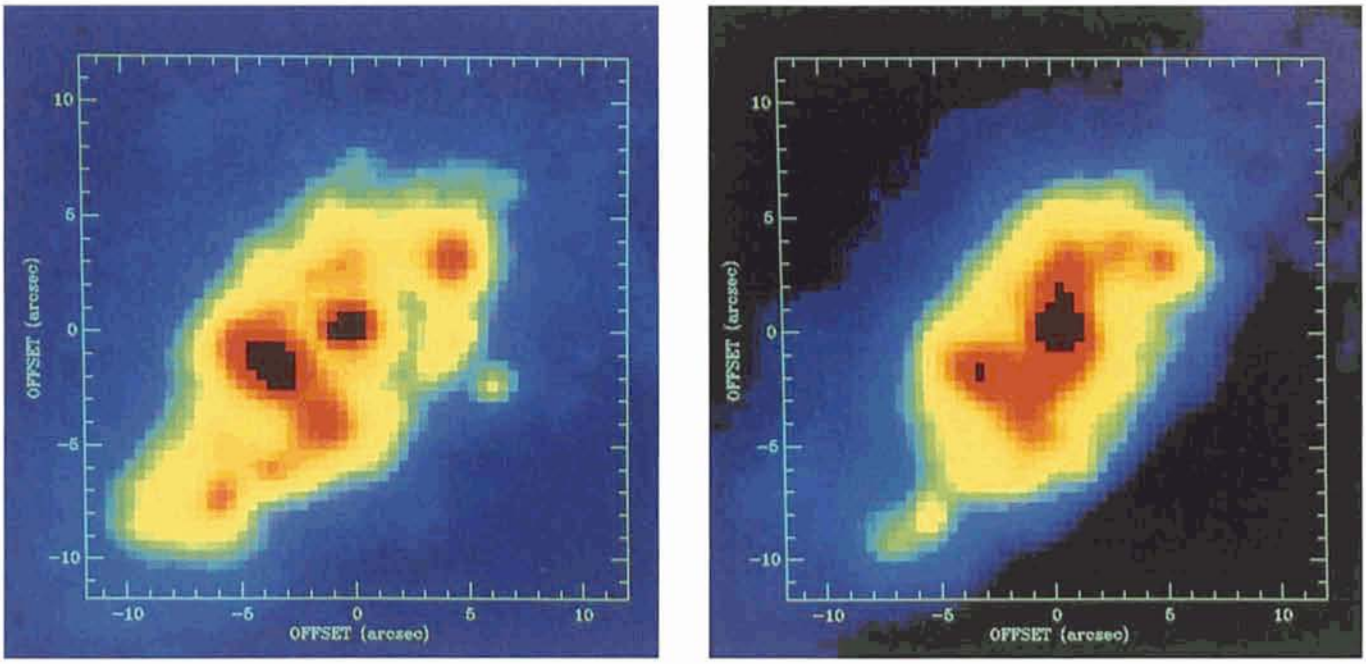


Figure 1: *Displayed here is the nuclear region of the starburst galaxy NGC 1808. (North is to the top and east to the left.) (a) The H$\alpha$+[NII] emission at $\lambda$ 6570 Å. Numerous "hot spots" (= bright HII regions) seem to be distributed along a ring of radius 8". The nucleus at position (0,0), which is slightly offset from the ring centre, shows signs of nuclear activity. (b) The I-band continuum emission at $\lambda$ 9137 Å. Due to the altered relative intensities of the bright condensations, their distribution appears quite different compared with the above image. Especially peculiar is the "hot spot" 5" SE of the nucleus, which is not very prominent in the continuum image, but has about the same brightness as the nucleus in the H$\alpha$+[NII] line emission.*

Array (VLA) in the radio continuum and HI $\lambda$ 21-cm emission line (Koribalski et al. 1992a, b) in order to study the overall gas dynamics in the disk and a possible large-scale flow of matter from the disk into the halo, as suggested by the structure of the dust filaments in the nuclear region of this galaxy. A very valuable addition to these data sets were the above-mentioned optical observations obtained with the 3.5-m NTT during commissioning time for EMMI, the ESO Multi Mode Instrument, in October 1991 (for a description of EMMI see *The Messenger* **61**, p. 51). Both long-slit spectroscopy in the red near H$\alpha$ and direct imaging (H$\alpha$- and I-filter) were carried out. The observing parameters are summarized in Table 1. The data reduction was carried out with the MIDAS software package.

## 3. Results

In this preliminary report we will concentrate on two peculiar features in the distribution of H$\alpha$ emission which might be of interest for understanding the relation between starburst nuclei and the kinematics of the host galaxy on larger scales. The H$\alpha$-image obtained with EMMI shows

(1) a "mini-spiral" or nuclear ring describing the distribution of "hot spots" in the central region of NGC 1808 and

(2) a linear structure of bright HII regions on kpc scales. This is correlated with a ridge of neutral hydrogen (HI) gas and continuum emission in the disk.

### *3.1. The "hot spot" region*

In Figure 1 we show the colour coded intensity distribution in the central region for emission lines and stellar continuum. Figure 1a displays the light distribution of the H$\alpha$+[NII] emission lines. The pure line emission has been obtained by subtracting the scaled I-band continuum image (Fig. 1b) from the narrow-band H$\alpha$-image. One can distinguish a number of bright components, the so-called "hot spots", which are distributed over an area of about 1 kpc (20"). They seem to lie along a "mini-spiral" or nuclear ring of radius 400 pc and inclination 60° ($\approx$ the disk inclination). Its centre is slightly offset from the nucleus (= position 0,0). The continuum image (Fig. 1b) reveals a slightly different structure, with the nucleus being much more prominent (see also Fig. 2b, dotted line) than in the H$\alpha$ image.

The most accurate position of the nucleus, which is identical with the brightest component at several wavelengths, has been determined at $\lambda$ 6 cm with $\alpha$, $\delta$ (1950) = $05^h05^m58^s.56$, $-37°36'36''.3$ (Saikia et al. 1990). The other compact radio components observed at $\lambda$ 6 cm do not correlate with any of the "hot spots" and are probably supernova remnants.

With the H$\alpha$ spectrum taken at a position angle of PA = 145° (roughly along the major axis) we are able to get some insight into the central gas kinematics. Figure 2a displays the "hot spot" region as in Figure 1a but now the x-axis is oriented along the slit (y $\approx$ 0). The other plots of Figure 2 show the fit parameters of the H$\alpha$ line along the slit: (b) the relative intensity profile, (c) the position-velocity diagram, and (d) the line width FWHM, not corrected for instrumental broadening. The dotted line in Figure 2b is just for comparison and shows the I-band emission on an enhanced scale.

The rotation curve obtained from this spectrum (Fig. 2c; not corrected for the inclination) reveals a systemic velocity of about $v_{sys} = 985$ km s$^{-1}$ at the location of the nucleus. It is very symmetric in the inner $\pm$4"–5" where radial velocities of $v_{sys} \pm 115$ km s$^{-1}$ are measured. Further out we derive extrema of +130 km s$^{-1}$ and −180 km s$^{-1}$ at about 10" NW and 12" SE from the nucleus, respectively. The two "hot spots" on the SE side of the continuum (in Fig. 2b the two peaks to the left) cause an additional component which is responsible for the asymmetry of the rotation curve at this slit position. The rotation curves obtained by Burbidge & Burbidge (1968) and Véron-Cetty & Véron (1985) do not resolve this inner region.

The width of the H$\alpha$ line (Fig. 2d) has an interesting radial dependence which is directly related to the rotation curve and the nuclear environment. In the

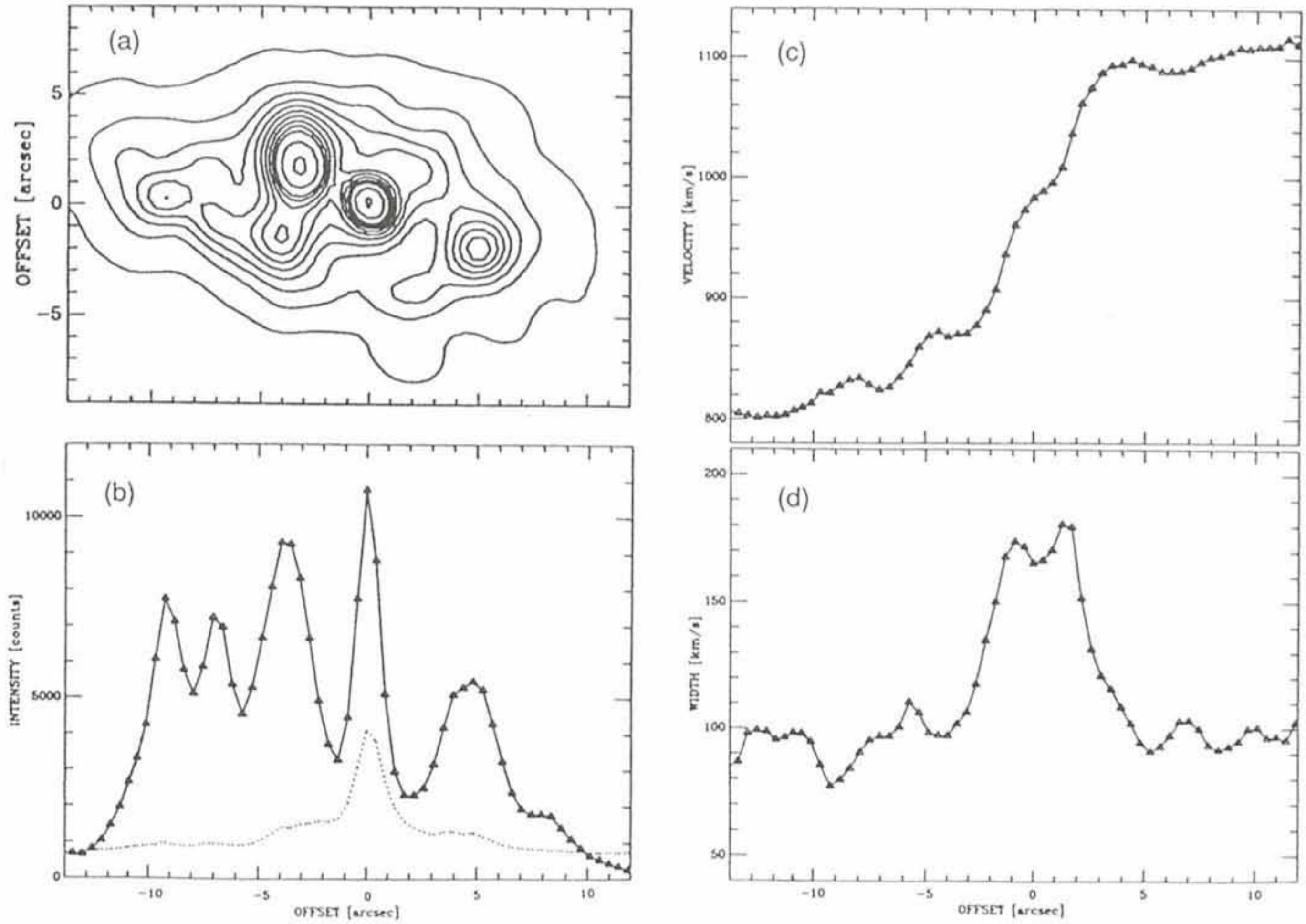


Figure 2: *(a) The "hot spot" region of NGC 1808 as in Figure 1a but with the x-axis oriented along the slit (PA = 145°) where the Hα spectrum was obtained. Further displayed are (b) the relative intensity profile of the Hα line emission (solid curve) and continuum emission (dotted curve), (c) the position-velocity diagram, and (d) the width (FWHM) of the Hα line.*

same range where the rotation curve is symmetric, the width of the Hα line starts to increase from 100 km $s^{-1}$ to unusually large values, reaching about 180 km $s^{-1}$ near the nucleus, and slightly less at the nucleus itself. The enormous line width at the position of the nucleus as well as the observed asymmetric line profiles and increasing [NII]/Hα ratios (which will be discussed elsewhere) are hinting at nuclear activity as had already been suggested by Véron-Cetty & Véron (1985).

### *3.2. The bar*

We will now concentrate on the disk of NGC 1808 which has an optical extent of $7'.2 \times 4'.1$ along PA = 133° ($B_{25}$, de Vaucouleurs et al. 1976). The direct image of NGC 1808 obtained in the red channel of EMMI is already displayed in the ESO Annual Report 1990 (p. 56–57). Our Figure 3 shows the Hα+[NII] line emission from the disk of NGC 1808 which is mainly confined to a thin line of numerous bright HII regions and reveals only a small amount of diffuse emission.

The alignment of the HII regions from –60″ SE to +60″ NW of the nucleus and the correspondence of this linear structure with a ridge in the HI distribution as well as the elongation of the radio continuum distribution in the same direction strongly suggests the presence of a *bar*. The linear dimension of the bar is ≈ 6 kpc at a position angle of PA = 155° which is about 20° offset from the PA of the disk. The ratio of bar to disk length is roughly $D_{bar}/D_{25}$ = 0.3. Beyond ±3 kpc the HII regions bend in opposite directions following the galactic rotation, which is also observed in the distribution of neutral hydrogen gas.

Table 1. *Observing Parameters*

| | |
|---|---|
| Telescope | 3.5-m New Technology Telescope |
| Observer | S. D'Odorico (ESO) |
| Date | 1990, October 23/24 |
| Instrument | ESO Multi Mode Instrument |
| Type of CCD chip | $1024^2$ THX Thompson |
| Observing mode: | |
| *(A) Long-slit spectroscopy* | |
| Slit-length, slit-width, PA | 6′, $1''.2$, 145° |
| Grating, dispersion | #6, 28Å/mm |
| Resolution | 1.2 Å ≙ 55 km $s^{-1}$ |
| Integration time | Hα-spectrum: 30 min |
| *(B) Direct imaging* | |
| Field dimensions | $7'.5 \times 7'.5$ (– > $0''.44$/pixel) |
| Filters (number, centre, width) | #596 (Hα), 6570 Å, 72 Å<br>#656 (I), 9137 Å, 194 Å |
| Integration time | Hα-image: 5 and 10 min<br>I-image: 10 min |
| Resolution | ≈ 3 pixels |

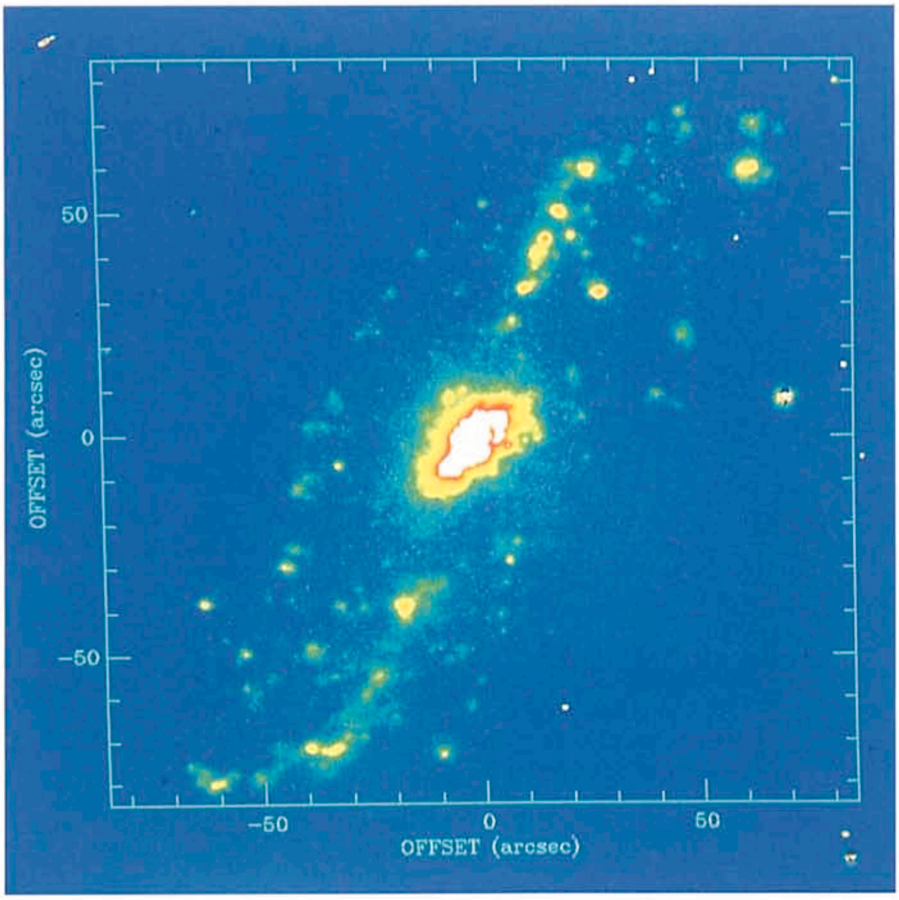


Figure 3: *The disk of NGC 1808. The Hα+[N II] line emission is mainly observed along a line at PA = 155°. This linear structure extends roughly 3 kpc to both sides of the nucleus and further out bends in opposite directions following the galactic rotation. (North is to the top and east to the left).*

To determine the velocities in and around the bar it is now necessary to obtain further spectra at various position angles.

## 4. The Scenario

The question arises, what is the physical connection of the different features described above. In the following we describe a scenario which tries to answer this question.

The clue to the scenario is *the bar*. The presence of a bar potential strongly influences the gas flow in the disk and the nuclear region of a galaxy. Galactic disks are very sensitive to m=2 resonances, and it is therefore expected from stellar dynamical studies that bars can easily be excited by gravitational interaction (e.g. Athanassoula 1990). The warp of the outer spiral arms in NGC 1808 (see Koribalski et al. 1992a) could be the result of a recent tidal interaction with the neighbour galaxy NGC 1792, located at a projected distance of about 130 kpc. The bar in NGC 1808, which is not seen in the visual light, is clearly detected in optical emission lines and less pronounced in the neutral hydrogen and radio continuum emission. The curved dust lanes in the disk of NGC 1808 (see Laustsen et al. 1987) could correspond to shocks induced by this 6 kpc bar.

According to Combes & Gerin (1985) a bar causes molecular clouds inside corotation to stream towards the centre and to accumulate at the Inner Lindblad Resonance (ILR). The crowd of clouds at this specific radius is often observed as a nuclear ring. In NGC 1808 the resonance location is denoted by a ring or spiral of "hot spots" (Fig. 1) enveloped by a fast rotating torus of cold gas (Koribalski et al. 1992b). A similar scenario is for example found in the barred galaxy NGC 2903 (Jackson et al. 1991).

CO measurements obtained with the SEST show a high concentration of molecular gas in the central area (Dahlem et al. 1990). The FIR/CO(1–0) luminosity ratio which is often used as a measure of massive-star formation efficiency is about 20 $L_\odot/M_\odot$. Due to the low resolution of the data we have no information about the molecular gas distribution in the bar.

Finally, the observed *outflow* of neutral and ionized gas from the central starburst region into the halo of the galaxy NGC 1808 (Koribalski et al. 1992a, Phillips 1992) might be the consequence of the accretion of cold gas near the centre, at the location of the ILR(s). Reaching the nuclear region, it will be heated and, due to the gas pressure of supernovae and winds, ejected along the rotation axis of the galaxy. The radial dust filaments emerging from the central region of NGC 1808 to at least 3 kpc above the plane clearly show the large energetics involved in this process.

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# New ESO Preprints

## (December 1992 – February 1993)

### Scientific Preprints

887. E.J. Wampler et al.: The Absorption Spectrum of QSO 2116-358 *Astronomy and Astrophysics.*
888. F. Matteucci et al.: Constraints on the Nucleosynthesis of Cu and Zn from Models of Chemical Evolution of the Galaxy. *Astronomy and Astrophysics.*
889. Xiao-wei Liu et al.: Observations of the Bowen Fluorescence Mechanism and Charge Transfer in Planetary Nebulae II. *Monthly Notices of the Royal Astronomical Society.*