sen and West, 1980, Whitmore et al., 1987); in Figure 1 the ring is visible as a disk-like feature almost oriented north-south and SN 1990I is located close to its southern edge. Although it cannot be exluded that the alignment of the SN 1990I with the polar ring is a projection effect, it is more probable that the SN was really formed in the ring.

The possibility that SN 1990I is of type Ia and is associated with the ring, makes this object particularly interesting, because the ring has quite blue colours, is knotty and very rich in HII regions indicating significant recent star formation (Laustsen and West, 1980); on the other hand, SN type Ia are typical of galaxies in which no young stellar population is present and it is generally agreed that Ia supernovae are associated with a low mass, old population (Woosley et al., 1986).

The location of SN 1990I would not be unusual if, instead, we were dealing with a type Ib, which are thought to have massive progenitors. Since the number of spectroscopically and photometrically well-sampled supernovae Ib is rather small, the follow-up of SN 1990I is very interesting, even if it should turn out not to be of type Ia.

The favourable location of SN 1990I in the sky will allow La Silla observers to follow it during the next 5 months or so.

Acknowledgements

Special thanks and congratulations go to O. Pizarro, who discovered SN 1990I in his long-term survey of Schmidt plates. I also appreciate the help of M. Bahamondes, J. Miranda and J. Borquez in obtaining some of the early observations, as well as several visiting astronomers, who kindly spent part of their time observing SN 1990I: V. Burwitz, D. Pollacco and J.P. Sivan. Finally, I am grateful to B. Leibundgut and E. Oliva for helpful discussions.

Latest News

According to M.M. Phillips, CTIO, spectra of SN 1990I show that it is of type Ib (IAUC 5032; June 14, 1990).

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The Stellar Content of the Dwarf Galaxy NGC 3109

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1. Introduction

Despite their modest appearance, dwarf irregular galaxies (DIGs) form an interesting class of objects in many respects. First, the high mass-to-light ratios measured for the smallest systems make DIGs some of the best candidates for the study of the dark matter content of the universe. Observations suggest that the ratio of hidden-to-luminous matter increases when going from irregular systems such as Sextans

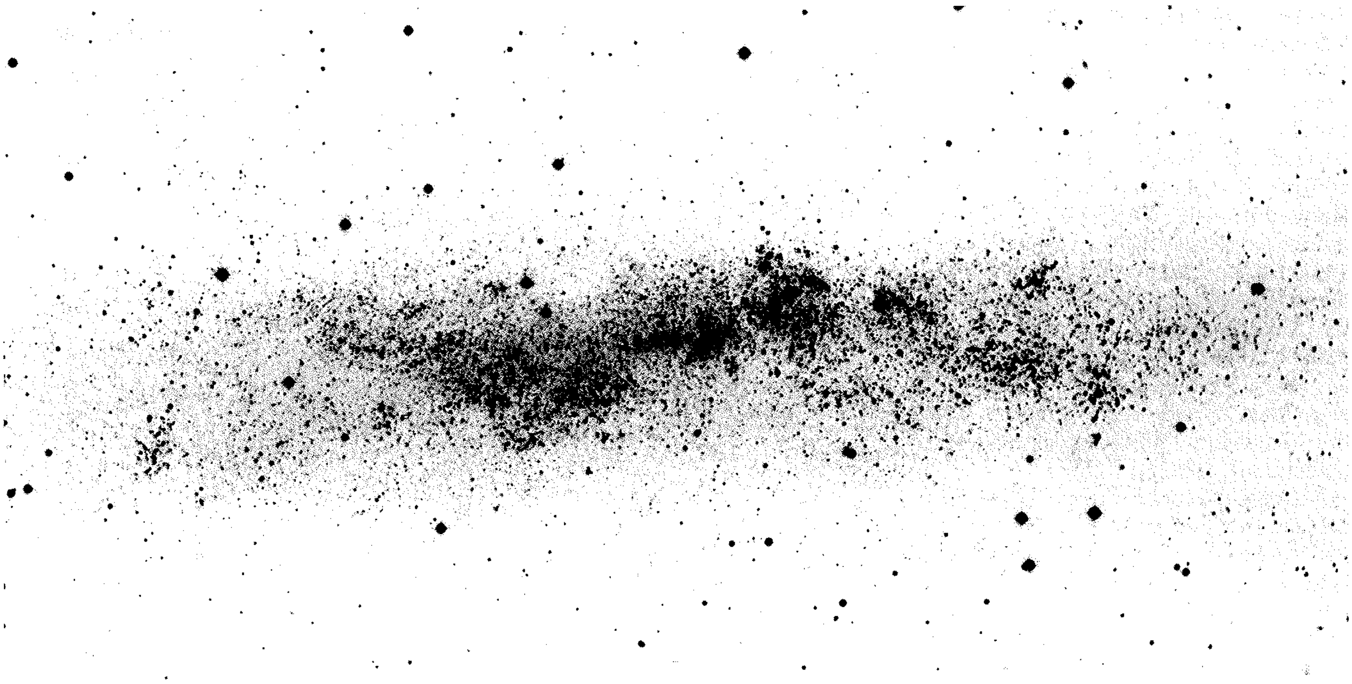

Figure 1: *The SBm galaxy NGC 3109 from an ESO 3.6-m 60-min exposure on Kodak IIIa-J + GG 385.*

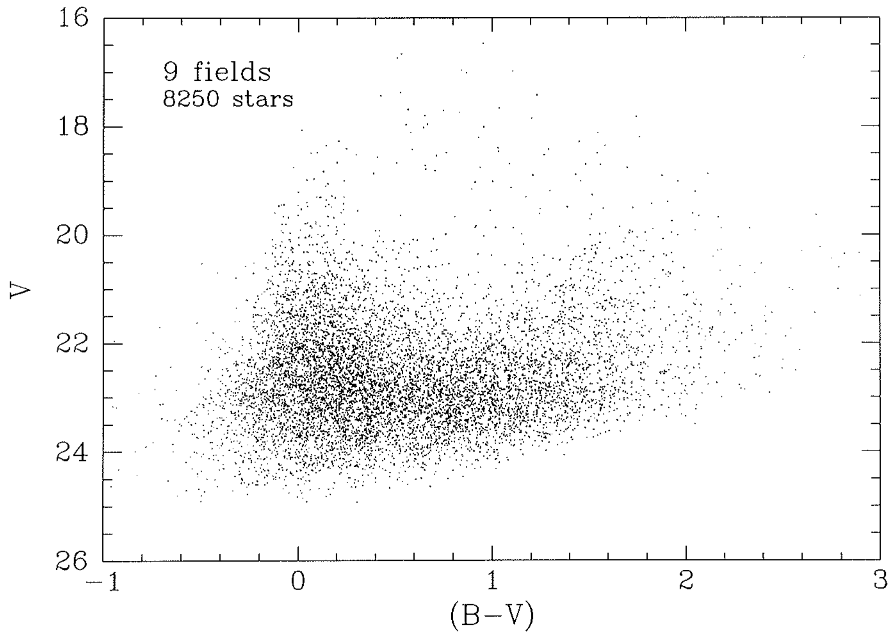

Figure 2: *C-M diagram of the stars projecting on the 21′ × 3′ region centred on NGC 3109, not corrected for field star contamination.*

A and LGS 3 towards the smaller dwarf spheroidals Ursa Minor and Draco (cf. Trimble 1987).

Second, since DIGs are generally believed to be simple and rather unevolved objects, they are excellent laboratories to study the early phases of the chemical evolution of galaxies. Spectrophotometric investigations have revealed that the metal content is generally low, ranging from approximately a few hundredths to half of the solar value. The low metallicity is of consequence in cosmology, since it favours the estimate of the primordial abundance of Helium, a figure of paramount importance in testing the Big Bang theory. Furthermore, DIGs are probably the most common galaxies in the universe; this too can be of cosmological interest in that it bears on the theories of galaxy formation as well as on the estimate of the total mass of the universe.

Third, DIGs play some role in the problem of the cosmic distance scale: Cepheid variables have been identified in the nearest galaxies, and used to estimate their distance moduli. These measurements have led to the extension of the faint end of the relation between luminosity of the brightest blue and red supergiants and absolute magnitude of the parent galaxy (Humphreys, 1983). Such a calibration is of great importance for the determination of distances to more distant galaxies in which Cepheids can no longer be seen.

Finally, given their structural simplicity (e.g. lack of spiral arms), DIGs are better places than the more complex and larger spirals, to study star formation processes. Such processes can be spectacular in dwarf irregulars, especially in the blue compact galaxies. The intense activity relatively to the small sizes of these galaxies accounts for their blue colours and for the presence of several associations of young stars; the latter are often embedded in large clouds of ionized hydrogen, and give these galaxies their clumpy and knotty appearance. The availability of great reservoirs of gas supports the belief that dwarf irregulars are young and still relatively unevolved galaxies with regard to star formation. The question of whether star formation is a continuous process or rather a sequence of single bursts, is still controversial. The burst model is usually preferred in interpreting the properties of the blue compact galaxies, while more normal DIGs are thought to experience a continuous and constant activity (Hunter and Gallagher, 1985).

More than a dozen DIGs have already been identified in the neighbourhood of the Galaxy, and so close that their stellar content is quite well resolved. The availability of software packages allowing photometry in crowded fields, such as DAOPHOT or ROMAFOT, has permitted the construction of C-M diagrams for a certain number of these objects (Table 1). Combined with stellar evolution models, these measurements have shed some light on the characteristics of the stellar populations of the nearest galaxies, showing similarities in their content of massive stars, as well as in the shape of the Initial Mass Function.

We have recently undertaken a systematic programme for the study of the stellar populations in some nearby DIGs through multicolour CCD photometry. Material has already been collected for UKS 2323, IC 1613, and NGC 3109, and a first account of the results obtained for UKS 2323 has been given by Capaccioli et al. (1987). Here we present some new results concerning a classical photometric target, NGC 3109.

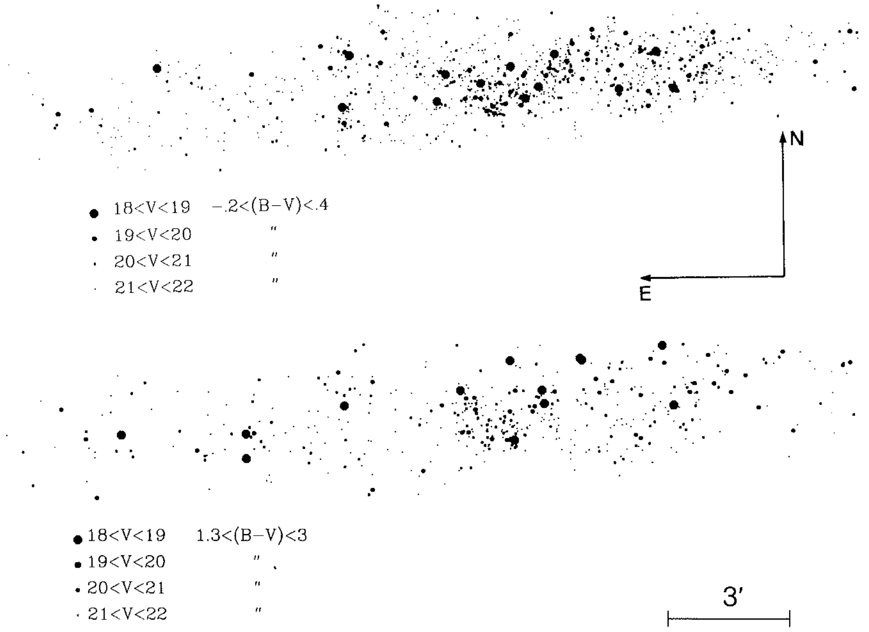

Figure 3: ***Upper panel:*** *projected distribution of the brightest blue stars of NGC 3109 contained in the diagram of Figure 2; the central bar and the two eastern spiral arms are discernible.* ***Lower panel:*** *map of the brightest red stars.*

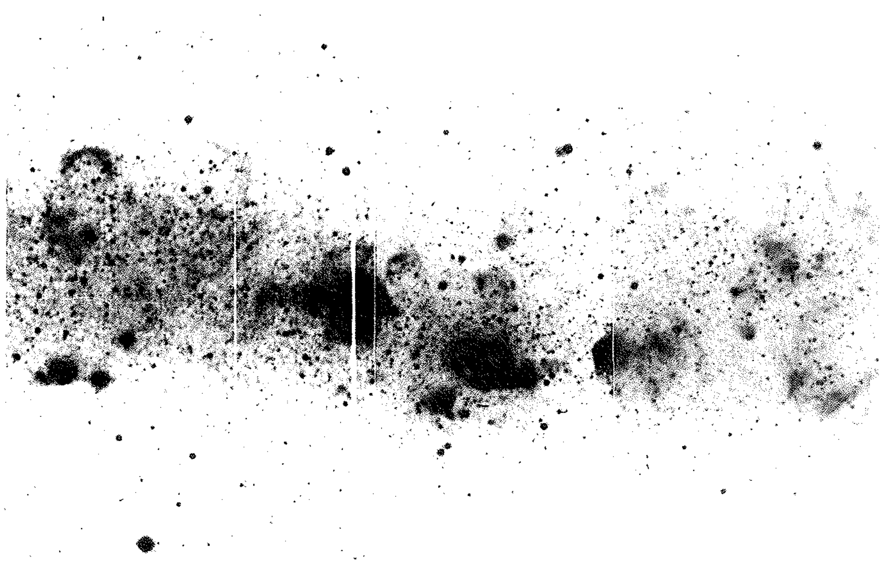

Figure 4: *Mosaic of three CCD frames of NGC 3109, centred on the west end of the bar and taken through an Hα filter.*

tance modulus 0.3 mag smaller than given by SC. The mean internal error, as given by DAOPHOT, ranges between 0.01 mag at $V = 18$ and 0.1 mag at $V = 23$. These figures, however, have to be regarded as lower limits of the internal errors, as shown by Piotto et al. (1990).

The final C-M diagram for 8250 stars identified in 9 fields is reproduced in Figure 2. Two fields were not observed under photometric conditions, and could not be accurately calibrated; moreover, ~15% of the stars happened to have formal error >0.1 mag, or $\chi > 1.8$ (Stetson, 1987), and were thus rejected. As can be seen, the brightest stars of the main sequence have $V = 18$, which corresponds to $M_V \simeq -8$. We like to stress here that, from the point of view of surface covered and number of stars measured, ours is one of the most complete CCD samplings of the stellar

2. NGC 3109: Observations and Data Reduction

NGC 3109 = DDO 236 (Fig. 1) is a magellanic spiral located at the periphery of the Local Group: its distance modulus, based on Cepheids, is $(m\text{-}M)_B \simeq 26$ according to Sandage and Carlson (1988; hereafter referred to as SC). While comparable to the Small Magellanic Cloud from the point of view of luminosity ($M_B = -16$), the size of NGC 3109 makes it one of the largest magellanic systems known so far (D = 14 kpc, corresponding to $0\overset{\circ}{.}5$ on the sky). Previous studies of its stellar content are by Demers et al. (1985) and by SC; both of them are based on photographic material.

Our observations were made during three different runs at ESO, La Silla, in March and May 1988, and in March 1989, with the CCD cameras of the Danish 1.5-m and the ESO/MPI 2.2-m telescopes. We collected B and V images of 11 fields of the galaxy, distributed in such a way as to cover a total area of $\sim 21' \times 2'$. The six central fields were also imaged through an Hα filter (and in a contiguous band). Deep exposures and fair seeing conditions (FWHM = $0''.9-1''.2$), allowed to measure stars down to magnitude $V \simeq 24$ using DAOPHOT. Instrumental magnitudes were calibrated by a large set of standard stars (Landolt 1983a, b). The zero point errors of our photometry are estimated to be ~0.03 mag in V and 0.05 mag in (B-V). Note that the comparison of ~200 stars in common with SC has revealed the presence of a systematic difference in the zero point, our photometry being 0.3 mag brighter than SC's; in other words, our scale implies a dis-

TABLE 1: *Stellar photometry in dwarf irregular galaxies*

Object	Distance modulus	Ref.	Material used	No. of stars measured
NGC 6822	23.5 mag	1	phot.	–
		2	CCD	3475
IC 1613	24.5	3	phot.	318
		4	CCD	2224
WLM	25.0	5	phot.	68
		6	CCD	2250
LGS 3	25.0	7	CCD	66
GR 8	25.7	8	CCD	84
		9	CCD	142
UKS 2323	26.0	10	CCD	204
NGC 3109	26.0	11	phot.	–
		12	phot.	83
Pegasus	26.1	13	phot.	54
		14	CCD	–
Sextans A	26.2	15	phot.	70
		16	CCD	652
		17	CCD	2279
Sextans B	26.2	18	phot.	77
		19	CCD	1273
Leo A	27.1	20	phot.	92
		21	phot.	–
Sculptor	27.3	22	phot.	33
Ho I	27.5	23	CCD	279
Ho II	27.5	23	CCD	468
Ho IX	27.5	24	CCD	367
DDO 187	28.8	25	CCD	77

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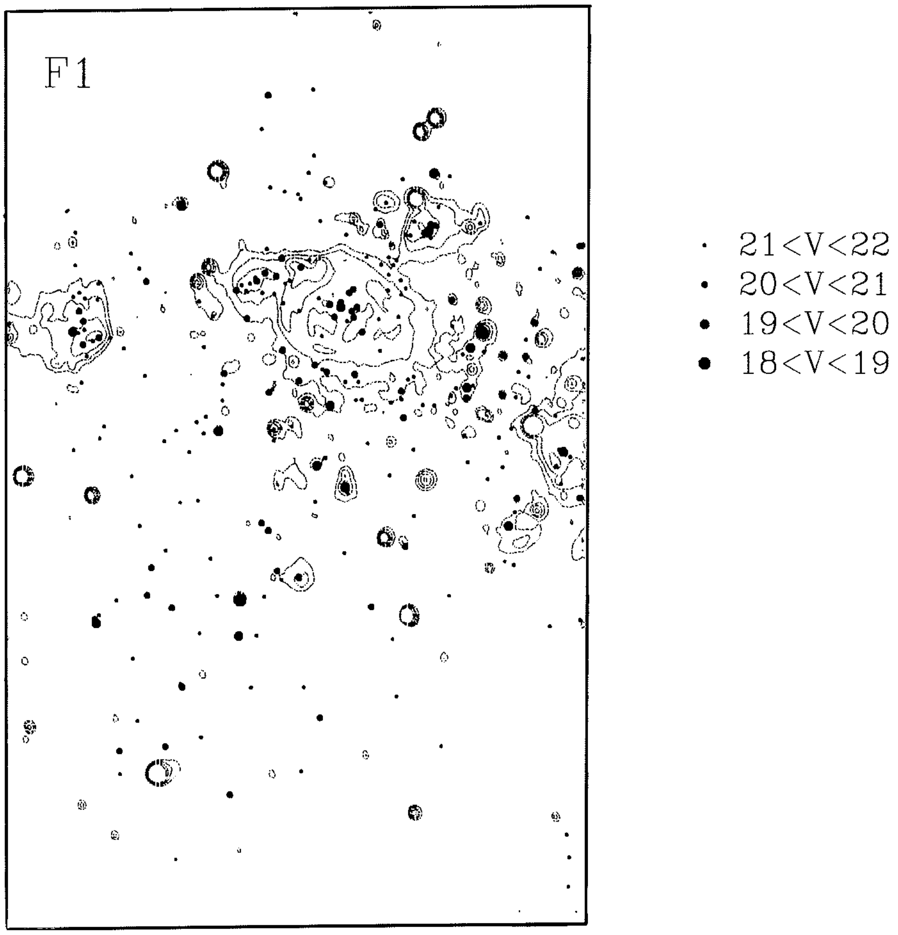

Figure 5: *Isophotes of the HII regions contained in one of the central Hα field of NGC 3109, superposed to the distribution of the brightest blue stars.*

content of a dwarf galaxy besides the Magellanic Clouds (cf. Table 1).

3. The Young Stars

The top panel of Figure 3 shows the distribution of the brightest blue stars, reconstructed by selecting only stars with 18 < V < 22 and –0.2 < (B-V) < 0.4. In a similar way we have built the map of the brightest red stars [(B-V) > 1.4] shown in the lower panel of the same figure. The photometric data base pertains to 11 fields, covering more than 20′ of the galaxy in the direction of the long axis.

The central bar of NGC 3109, described by de Vaucouleurs and Freeman (1972), stands out in the blue map, together with the two eastern spiral arms, which are well seen in wide-field photographs. Moreover, the overall distribution of the blue stars appears rather clumpy. These structures are absent or barely visible in the red map, where stars seem more evenly distributed. We do not measure any appreciable difference in the scale heights of the two populations of stars.

The distribution of the young blue stars has also been compared to that of the HII regions provided by the Hα images. Very spectacular HII regions are present along and in proximity of the bar (Fig. 4). They are well confined to a ~300 pc thick stripe, with a maximum density a few arcminutes to the west of the optical centre. We have drawn the isophotes of these regions, and superimposed the blue star distribution. In general, the brightest blue stars and the main stellar associations are found inside HII regions, as can be seen in Figure 5, which reproduces one of the more central fields. The great star-forming region near the centre, just at the west end of the bar, is about 250 pc across.

We selected about 30 star-forming regions using the Hα images, and produced a C-M diagram for each one of them. The number of stars varies from a few tens to about a hundred. Due to the small angular size of these stellar associations, crowding effects are important, making the photometry rather uncertain at magnitudes fainter than V = 22. This approach has the advantage of isolating the young stars from the uniform background of old stars, which enables us to create a map of the most recent episodes of star formation over the whole surface of the galaxy image.

We have estimated the ages of the star-forming regions using theoretical isochrones kindly made available to us by the group of Prof. C. Chiosi. Unfortunately, internal absorption and metal content of NGC 3109 are still uncertain; therefore, only a rough superposition of the theoretical curves to the C-M diagrams is possible, allowing an arbitrary (but small) shift along the colour index axis. On the other hand, this procedure

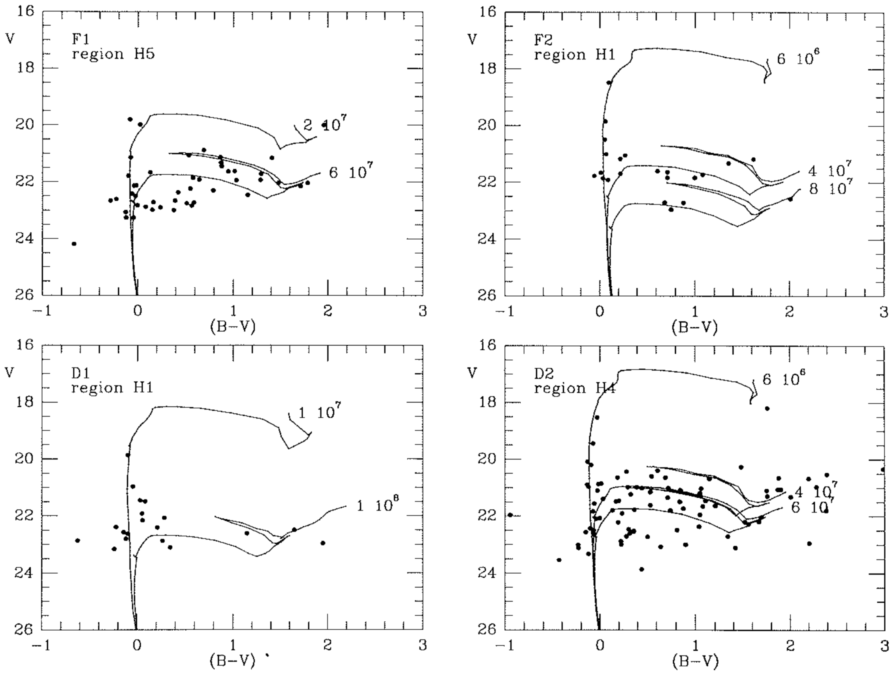

Figure 6: *C-M diagrams of four star-forming regions. Isochrones provided by C. Chiosi and calculated for a solar metallicity have been matched to the observations, allowing an arbitrary shift in colour. The corresponding ages (in years) are indicated.*

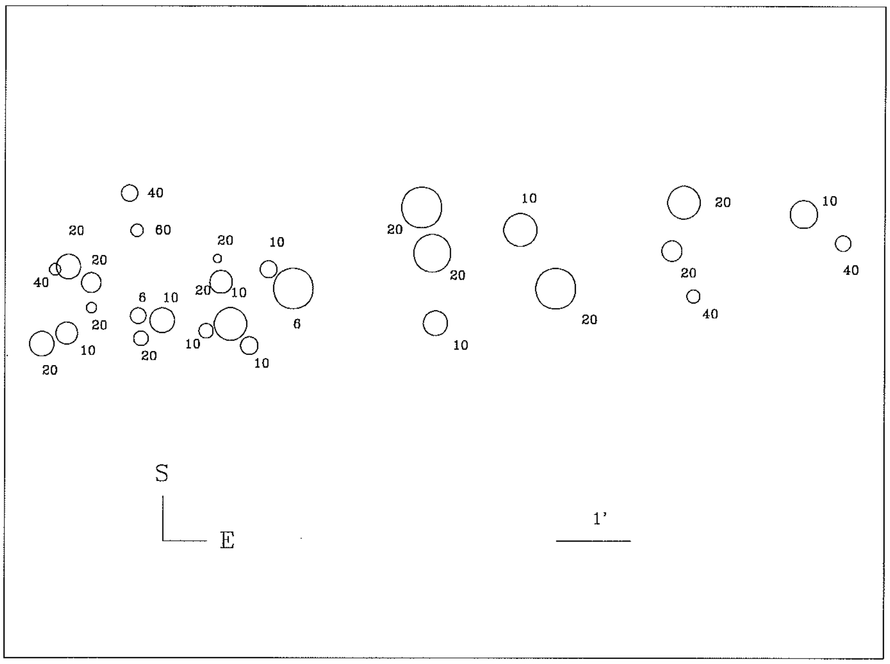

Figure 7: *Map of the star-forming regions selected in the six central fields; the radii of the circles are proportional to the size of the regions. Ages (in* 10^6 *yr) of the youngest stars found in the C-M diagrams are indicated.*

is accurate enough to get an estimate of the ages of the single regions. We have used models calculated for a solar metallicity and adopted the internal absorption values given by SC. A larger extinction correction had to be adopted for star-forming regions belonging to the central parts of the galaxy. An example of the procedure is shown in Figure 6.

We find that the youngest stars of NGC 3109 have ages of the order of $\sim 6 \times 10^6$ years, with masses $\sim 30\ M_\odot$; in other words, this galaxy is still active in forming stars. Moreover, since the part of the diagrams corresponding to ages of 20–100 million years appears rather uniformly populated by stars, we may conclude that, in this time interval, stars have formed in an almost regular manner (see the plot in Fig. 7, where sizes and ages of the selected regions are shown). A comparison with similar work on other resolved DIGs shows that the level of recent star formation in NGC 3109 is quite high, a fact which is probably related to the size of the galaxy.

Acknowledgements

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Probing the Hidden Secrets of Seyfert Nuclei

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The nuclei of active galaxies are clearly among the most spectacular and violent places that can be found in our present universe. Most extreme are the bright Quasars, where we observe a total energy output equivalent to a large galaxy cluster from galactic core regions comparable in size to our solar system. In addition to optical and radio radiation we often observe intense X-ray and even energetic Gamma radiation as well as collimated streams of matter moving at velocities close to the velocity of light.

Most currrent theories assume that the enormous radiation power of active galactic nuclei (AGNs) is produced by massive rotating black holes residing in the dynamical centres of these galaxies. Swallowing surrounding material at rates up to about one earth mass per second, such black holes give rise to huge rotating magnetic fields and electric current systems which can explain the astonishing properties of these systems.

However, in spite of a large research effort during the past decades we are still lacking a reliable observational confirmation of the basic physical models of the AGNs and our knowledge of the detailed physical processes occurring in AGNs is still highly incomplete. One reason for the slow progress of our understanding of the AGNs is the great distance of most active galaxies which makes it impossible to resolve the active nuclei by direct imaging techniques. Furthermore, during the past decade it became increasingly evident that in many AGNs the central engines are not directly visible but hidden behind opaque dusty matter concentrations along the line of sight. Even in the case of nearby Seyfert galaxies (the nearest known examples of AGNs), direct optical radiation from the centre of the active nuclei seems to be observed only in exceptional cases. Moreover, when direct radiation is detected, it is often mixed with light of the normal stellar galactic core and with emission from circumnuclear normal H II regions ionized by stars.

Fortunately, modern observing techniques provide various methods to overcome some of the observational difficulties mentioned above. High-resolution