3D Optical Spectroscopic Methods in Astronomy
ASP Conference Series, Vol. 71, 1995
G. Comte, M. Marcelin, eds.

The distant (z=0.471) radiogalaxy 3C 435 A with the integral field spectrograph TIGER

B. Rocca-Volmerange

Institut d'Astrophysique de Paris, 98bis Bd Arago, F-75014 Paris and I.A.S., Université. Paris 11, F-91405 Orsay, France

G. Adam, P. Ferruit and R. Bacon

Observatoire de Lyon, F-69561 St Genis-Laval, France

1. Introduction

The distant radiogalaxies recently discovered at the most remote distances ($z \geq 3.5$) are among the best cosmological targets. However so various features caracterize these galaxies (red stellar energy distribution, huge emission lines, high density of galaxy companions, alignment of ultraviolet and radio axes, large degree of polarisation) that their structures are not simple to understand. Stellar populations will only become the best indicators of evolution of galaxies if these structures are clearly understood from a two-dimension spectroscopy on each image point. The integral field spectrograph TIGER is a unique instrument at the CFHT to give details on the nature and velocities of the various components of distant radiogalaxies.We present the observations with TIGER of an intermediate-redshift galaxy 3C435A (z=0.471) (Rocca-Volmerange et al, 1994). The two nebular lines [OII], [OIII] and the largely extended stellar continua are observable, allowing to date galaxy with the help of our evolution model. The present and past star formation activities and the origin of alignment will be thus analysed in terms of galaxy evolution.

2. Main properties of distant radiogalaxies

2.1. The stellar energy distribution

A typical gap of the continuum is observed from the blue to the red (through B and K filters), corresponding in the rest-frame to a plateau in the ultra-violet and a strong increase in the visible (Lilly,1988, Chambers et al,1990). Many interpretations based on populations of evolved stars (giants, supergiants, asymptotic giant branch stars) were successively proposed by various authors. But these interpretations did not take into account the huge nebular emission observed in these galaxies. Recent observations of a sample of distant radiogalaxies with the CGS4 instrument at the UKIRT (Eales et al, 1993) show intense [OIII] and Hβ lines. These redshifted lines contribute to the K band emission more than previously thought. After substracting these lines to the observed energy distribution, the stellar continuum fits a model of a very recent age ($\leq$0.5 Gyr), without adding any red population and confirming that at high redshifts, radiogalaxies are dominated by young stars (Rocca-Volmerange, 1993).

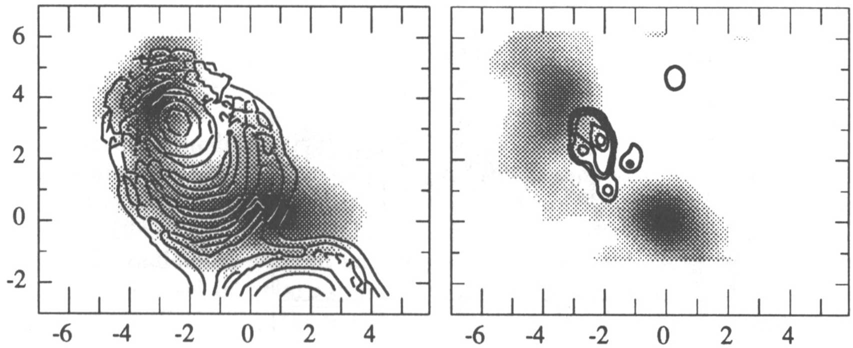

Figure 1. The gray-scale [OII] and [OIII] maps respectively superimposed to the 1.4(left) and 4.8(right) GHz radio isophotes.

2.2. The alignment of the UV and radio axes

Observed from a large sample of distant radiogalaxies (Mc Carthy et al, 1987, Chambers et al, 1987), this alignment rapidly increases with redshift. For nearby galaxies, this alignment is due to nebular emission (van Breugel et al, 1985) while at higher redshifts, the strong increase was attributed to other processes. Star formation was thus proposed in various models as triggered by the radio-jet (Bithell and Rees, 1989) or by interactions of the radio plasma with the intergalactic environment (Begelman and Cioffi, 1989, Daly, 1990, de Young, 1989),to be confirmed by observations.

3. Results on the star formation history

3.1. Nebular emission lines and polarisation

The Lyα emission line of powerful radiogalaxies reach more than 10^{44} ergs.s^{-1} with a 100 kpc diameter and a FWHM of 1000 km.s-1, as the famous example of the galaxy 3C326.1 (Mc Carthy et al, 1987). Other typical lines are enormous as the [OII] line a possible signature of star formation and the [OIII] and Hβ lines, observed in the near-infrared at high redshifts, better indicators of shocks, AGN or non-thermal effects.The physical origin is not well identified, in particular for the ionized [OII]3727Åline. Moreover the degree of polarisation and the orientation of the electric vector are useful indicators of the interaction of the relativistic electrons with the gas, even if recent data clarify the relation with radiogalaxy activity (Cimatti et al., 1994).

4. Observations of the radiogalaxy 3C435A

We present the results of the first radiogalaxy from a sample observed with TIGER at the CFHT from June 1991. The radiogalaxy 3C435A at z=0.471 forms an optical pair with 3C435B at higher redshift. Radio maps and a low level

https://doi.org/10.1017/S025292110002306X Published online by Cambridge University Press

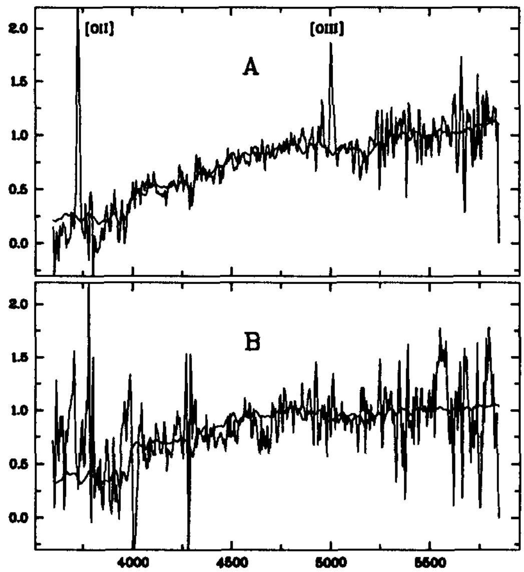

Figure 2. Spectra of the central and northern components fitted with our synthetic Atlas of galaxies

of polarisation (di Seregho Alighieri et al, 1993) bring complementary data. Observations cover the blue (5000-7000Å) and red (6500-8500Å) wavelength ranges with a spatial sampling 0."61 and a spectral sampling 8Å. The average seeing is 0"71. Data reduction has been carried out with the TIGER software package, installed on the MIDAS ESO software by Rousset, 1992.

Figure 1 shows the [OII](left) and [OIII](right) emission maps, respectively superimposed with the 1.4 GHz (Mc Carthy et al, 1987) and 4.8 GHz (Hutchings, private communication) radio isophotes. The alignment is evident as well as the identification of an interfacing zone with the intergalactic medium. The velocity field of the [OII] line is strongly distorted by many components as shown in Rocca-Volmerange et al, 1994. The ratio [OII]/[OIII] follows a crescent distribution along the radio lobe which peaks at the value 8. That excludes a scenario of star formation triggered along the central radio jet, as suggested by several models. A new result is the clear separation of the nebular and stellar emissions. Stellar continua are significantly observed in two companions, others being below the detection limit. Resulting from the sum of dispersed micropupils, these spectra are shown on Figure 2. The continuity of the slope from the V to the R bands confirms the availability of the data processing. Details of absorption lines show an evolved stellar population, in particular around the active nucleus, the interpretation of which is given below.

Several important results on the current and past star formation activities can be derived from these data. The [OII] and radio axis alignment is observed as in nearby radiogalaxies (van Breugel et al,1985). If the [OII] emission line is used as a possible signature of the present star formation, the curvature of the isophotes is not in agreement with a triggering along the central radio jet, as suggested by models. Here the [OII] emission only seems to trace zones of overpressured gas. In that case, the curvature of isophotes following the radio-plasma in expansion is in favor of the model of overpressured cocoon (Begelman and Cioffi, 1989). The peripherial shell of ionised gas merely explains the confinment of the radiolobes without any help of magnetic field. This scenario favors a current low level of polarisation as observed by di Seregho Alighieri et al, 1994, without eliminating the possibility of a stronger activity at earlier epochs. The stellar energy distributions (SED) of the central component A and of the north companion B (Figure 2) are indicators of the past activity. A fit of the SED by a minimisation procedure with our atlas of synthetic spectra of galaxies (Rocca-Volmerange and Guiderdoni,1988) gives respective ages of 14 Gyrs and 12 Gyrs at the redshift $z = 0$ in a low density universe which correspond to ages of globular clusters and means an old stellar population. A more statistically significant sample of distant radiogalaxies observed at increasing redshifts is in progress with TIGER at the CFHT to relate star formation activity with various power of radio jets, the environment density and the radiolobe confinment.

References

Bithell, M.,Rees,M.,1989,M.N.R.A.S.,242, 570

Begelman, M.C.,Cioffi, D.F.,1989, ApJ, 345, L21

Chambers, K., Miley, G., van Breugel, W.,1987, Nature, 329, 604

Chambers, K., Miley, G., van Breugel, W., 1990, ApJ, 363, 21

Cimatti, A., di Seregho Alighieri, S., Fosbury, R.A., Salvati, M., Taylor, D., 1993, MNRAS, 264, 421

Daly, R.A., 1990, ApJ, 355, 416

de Young, D.S., 1989, ApJ, 342, L59

di Seregho Alighieri, S., Cimatti, A., Fosbury, R.A.E., 1993, ApJ, 404, 584

Eales,S., Rawlings,S., Puxley,P., Rocca-Volmerange, B., Kuntz,K., 1993, Nature, 33, 14

Lilly, S., ApJ, 1988, 333, 161

McCarthy,P.J.,van Breugel,W., Spinrad,H., Djorgovski,S., 1987, ApJ, 321, L29

Rocca-Volmerange, B.,1992, 8e IAP meeting, Editions Frontieres, p.283

Rocca-Volmerange, B., Adam, G., Ferruit, P., Bacon, R., 1994, in press

Rocca-Volmerange, B., Guiderdoni, B., 1988, A & A Sup. Ser., 75, 93,

Rousset, A., 1992, Thèse de Spécialité de l'Université de St Etienne, France

van Breugel, W., Miley, G., Heckman, T., Butcher, H., Bridle, A., 1985, ApJ, 290, 496