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Research Note

The peculiar radio galaxy B2 1637+29: a high velocity encounter of two galaxy groups?

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Abstract. Radial velocity measurements are presented of several galaxies in the field of the peculiar radio galaxy B2 1637+29. We find that most galaxies are at the redshift of the radio galaxy, but a few also at that of the presumed companion of B2 1637+29. Since the difference in radial velocity between the two components is $\sim$ 4100 km s^{-1}, the data seem to indicate that the two galaxies of the B2 1637+29 system are not physically connected, and that the double galaxy system is most probably the result of a chance superpostion of two unrelated groups or clusters of galaxies at different distances. On the other hand the unusual radio structure suggests interaction between the two galaxies, and this possibility is reinforced by a recent investigation of Colina & de Juan, who found signs of interaction based on the optical properties of the system.

Some possible explanations of the system are given, but we conclude that for the moment the mystery of B2 1637+29 remains unsolved.

Key words: galaxies: clusters: general – galaxies: individual: B2 1637+29 – galaxies: interactions

1. Introduction

The radio source B2 1637+29, a member of the faint B2 sample of low luminosity radio galaxies (Fanti et al. 1978), has a very complex structure. In Fig. 1 we show a combined radio and optical image. The radio data were obtained with the VLA B configuration, at an observing wavelength of 20 cm (see De Ruiter et al. 1988 for details about the radio observations). The radio contours in Fig. 1 are superposed on a red POSS image, extracted from the Digital Sky Survey. The radio nucleus coincides with the southern galaxy, while a second galaxy, about 0.3 mag fainter, is located ~ 8 arcsec to the north. A third much fainter galaxy is just inside the envelope of the bright galaxy pair (see Fig. 1).

The radio source consists of a twin bent jet, which on the main jet side ends in a very bright lobe (absent on the counter-jet side), and two radio tails showing conspicuous oscillations. The structure suggests motion of the radio galaxy through an intergalactic medium, which causes the classical tailed radio structure, and dynamical interaction of the radio galaxy with a companion causing the oscillations in the radio tails. It appeared significant that the radio galaxy indeed has a close companion (separated by $\sim$8 arcsec), clearly visible in the CCD image shown in De Ruiter et al. (1988). However, spectroscopy revealed a surprisingly high difference in radial velocity ($\sim$4100 km s^{-1}), which leaves us with two equally improbable alternatives: either the “dumbbell” is a chance superposition of two unrelated galaxies, in which case the radio structure remains unexplained, or B2 1637+29 represents an interacting galaxy system, but with an extremely high velocity difference. A discussion about these possibilities was given by De Ruiter et al. (1988).

Of course, only extensive radial velocity measurements of field galaxies may answer the question whether there happen to be, for example, two superposed clusters of galaxies. Spectroscopic observations of a limited number of galaxies in the field of B2 1637+29 had been done at the same time as the spectra of the two components of B2 1637+29 (discussed in De Ruiter et al. 1988) were taken. These data are presented here. In Sect. 2 we briefly describe the spectroscopic observations, followed by a discussion of the results in Sect. 3.

2. The observations

Spectroscopy of a number of galaxies in the field of B2 1637+29 was done on June 26 and 27, 1987, using the combination of Intermediate Dispersion Spectrograph, 235 mm camera and Image Photon Counting System, mounted on the Isaac Newton Telescope (Observatorio Roque de Los Muchachos, La Palma,

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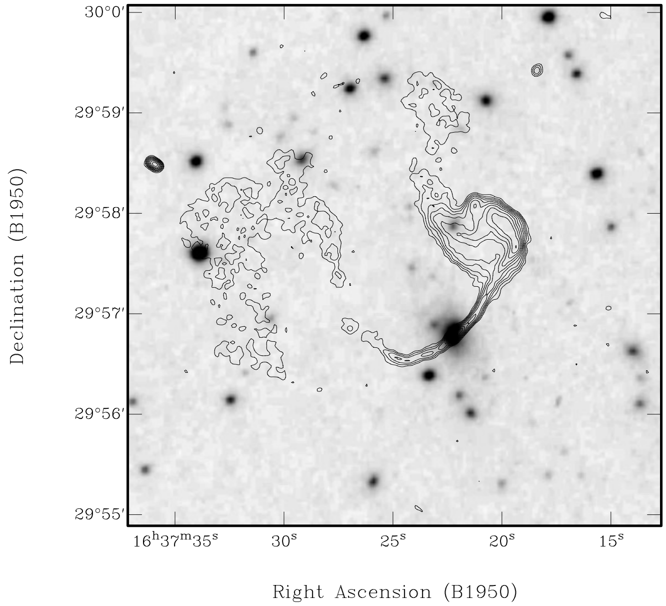

Fig. 1. The radio source B2 1637+29, superposed on an optical image reproduced from the Digital Sky Survey.

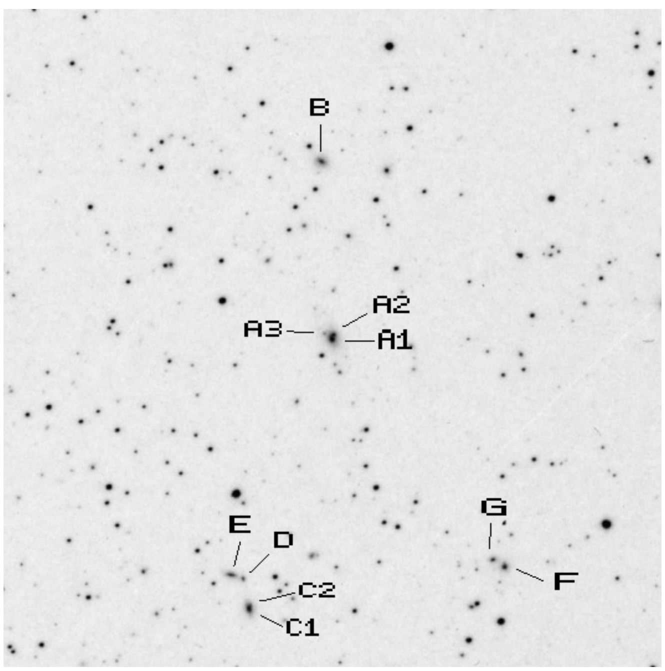

Fig. 2. The field around B2 1637+29, reproduced from the Digital Sky Survey. The image size is 15 by 15 arcminutes. A letter identifies the galaxies listed in Table 1.

Canary Islands). The galaxies observed are identified with letters in Fig. 2, which is a reproduction of a POSS red print. Note that B2 1637+29/A3 is a faint galaxy (or a filament) inside the envelope of B2 1637+29/A1 and A2.

A V400 grating was used, which gives a typical dispersion of 1.57Å/pixel, in the wavelength range covered between ~ 3600 and ~ 6700 Å. The spatial resolution in the direction perpendicular to the dispersion is 1.47 arcsec/pix. The slit width was always 300 μm, corresponding to ~ 1.5 arcsec, quite similar to the typical seeing on both nights.

Table 1. Heliocentric velocities for the observed galaxies

Object	$v_{\rm r}$ km sec^{-1}	$\sigma_{\rm v}$ km sec^{-1}
A1 (1st)	26424	17
A1 (2nd)	26415	18
A2 (1st)	31059	24
A2 (2nd)	31113	22
A3	25820	40
B	26165	27
C1	25563	15
C2	25438	36
D	30528	36
E	30538	27
F	26428	17
G	26141	27

The reduction of the data was done using the IRAF package. After flat fielding one dimensional spectra of the galaxies were extracted from the images, which were then wavelength calibrated using CuAr arc spectra taken immediately before or after the programme objects. The RMS of this calibration is typically ∼0.2 Å, but slightly degrading towards the red part of the spectrum (∼0.5 Å).

Cross-correlation of the spectra with the template spectrum of a K star gives the redshift, with un uncertainty of the order of 30 km s^{-1}. The radial velocities thus determined are shown in Table 1.

Both the radio galaxy B2 1637+29/A1 and its presumed component A2 were observed twice, and the radial velocities listed in Table 1 correspond to the results obtained from the first and second night.

3. Discussion

From the data given in Table 1 it is immediately clear that most (seven) of the observed galaxies are at the same redshift as the radio galaxy B2 1637+29/A1. In fact for these seven we find a mean radial velocity $< v >= 26000$ km s^{-1}, with a dispersion of 400 km s^{-1}. The radio galaxy does not have the mean radial velocity of this observed group of galaxies, but is off by ~ 420 km s^{-1}, which may indicate that it is not at rest with respect to the cluster but moving with a projected velocity of about 400 km s^{-1}. It should be noted that this is about the velocity assumed in De Ruiter et al. (1988) to explain the curvature of the radio jets.

However the most important result is that we also find two galaxies (D and E in Fig. 1) at approximately the same redshift as B2 1637+29/A2; the mean redshift of this group is $< v >= 30700$ km s^{-1}, with a dispersion of 300 km s^{-1}. Apparently there are two groups or clusters of galaxies at different redshifts, which have their cluster centers almost exactly along the same line of sight. The apparent dumb-bell system of B2 1637+29/A1 and A2 would then be an unfortunate statistical mishap, with an *a priori* probability of 2×10^{-3} (De Ruiter et al. 1988).

Recently Colina & de Juan (1995) have done a quantitative study on a large number of galaxies associated with FRI (low luminosity) radio sources, among which B2 1637+29. Specifically they studied peculiarities in the light distribution, which may be considered as signs of interaction ("signature of gravitational collision" in their words). The B2 1637+29 galaxy system ranks high in the list of possible interacting systems. One of the criteria they used is the presence of a close companion which we will ignore, as it was already discussed above. Of the remaining criteria, one gives a negative answer: no isophote twists larger than 15$^{\rm o}$ were seen. However B2 1637+29 does have significant isophote displacements and shows a significant excess over a de Vaucouleurs law as well. If we assume that A1 and A2 are at the distances indicated by their redshifts and therefore exclude physical interaction, the signs of interaction may be caused instead by A3, which indeed belongs to the same cluster as A1. A3 is much fainter (2–3 magnitudes), which makes it hard to understand why such a rather common interaction should have produced a strong flux asymmetry in the lobes and such conspicuously oscillating tails.

An alternative explanation is possible: if the two clusters are physically overlapping, in spite of their difference in radial velocity (~ 4000 km s^{-1}), then the high velocity encounter may have produced strong turbulence in the intra-cluster medium and this may give rise to the long oscillating tails. This may then be related to the phenomenon that goes under the name of cluster "weather" (see e.g. Burns et al. 1994). This alternative is perhaps not very attractive, because the Hubble flow is believed to be reasonably smooth, with deviations (for example due to "great attractors") much less than a thousand km/s, while here we would have to admit differences of $\sim$4000 km/s in the same region of space, not of a single galaxy but of entire groups of galaxies. On the other hand, if we dismiss this possiblity, we are left with the question why a rather anonymous galaxy located in a poor cluster of galaxies, with a background galaxy of similar magnitude at only 6 arcsec, produces such an unusual radio structure.

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