Restarting activity in radio galaxies

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Abstract

We present observations of two radio galaxies, J1835+620 and 3C338, both with signs of having passed through different stages of core activity. The former presents two symmetric and bright components within a typical FR II structure, possibly resulting from two distinct phases of activity; the latter is a FR I radio galaxy with two separated regions with different age properties, possibly due to a switch-off and -on cycle in its core. In both sources, the optical counterpart lies in a group of galaxies with indications of mutual interaction, a scenario often invoked to explain triggering of core activity.

1 Introduction

The large diversity of radio sources, partially understood as the result of orientation related effects (e.g. Urri & Padovani 1995), seems to suggest also an evolutionary process in the lifetime of a radio source. There is increasing evidence that Compact Symmetric Objects are young radio sources; that typical FR I and FR II radio galaxies may be considered “adult” sources; and finally, that many of the relic sources are probably associated with dormant radio galaxies which have ceased their nuclear activity. If we believe that the activity in radio-loud AGNs is the result of accretion onto a compact massive object, likely a black hole, the life of a radio source would be controlled by the accretion rate. Under such a scenario, it should be expected that a significant number of radio sources with clear evidences of having passed through
different phases during their lifetime are found. We present here observations of two such radio galaxies, J1835+620 and 3C338.

2 The Giant Radio Galaxy J1835+620

The radio source J1835+620 belongs to a new sample of large angular size radio galaxies (Lara et al., in preparation) selected from the NRAO VLA Sky Survey (Condon et al. 1998). We have observed this source with the VLA in its B- and C- configurations at 1.4, 4.9 and 8.5 GHz, and with the MPIfA 2.2m optical telescope in Calar Alto (Spain). The outstanding aspect of J1835+620 at radio wavelengths is the existence of two symmetric bright components (N2 and S2) within a typical FR II structure (Lara et al. 1999, Schoenmakers et al. 1999)(see Fig. 1). Its optical counterpart, coincident with the radio core (C) has a spectrum with strong and narrow emission lines. It lies in a group of at least three (probably four) galaxies showing signs of mutual interaction (Fig. 2). With an angular size of 3.88' and a redshift of $z=0.518$, implying a total source length of 1.12 Mpc ($H_0 = 75$ km s$^{-1}$ Mpc$^{-1}$; $q_0=0.5$), J1835+620 belongs to the group of giant radio galaxies.

We can interpret the peculiar structure of J1835+620 as the result of two distinct phases of core activity. However, the existence of a hot-spot in component N1 together with spectral aging arguments indicate that N1 and S1 are still supplied by fresh particles, implying i) the existence of an underlying jet connecting the core with the outer components and ii) that the activity in J1835+620 did not stop completely. In consequence, the new components N2 and S2 would represent the result of a new ejection propagating through the primary underlying jet. The parallel configuration of the magnetic field in components N2 and S2 (Fig. 1, bottom panel) is consistent with a “second-phase” jet which is overdense with respect to the “first-phase” one (Lara et al. 1999).

3 The FR I Radio Galaxy 3C338

3C338 ($z = 0.030$) is a FR I radio source, associated with the multiple nuclei cD galaxy NGC 6166 at the center of the cooling flow cluster of galaxies A2199. We are undertaking a program of VLA and VLBI observations of 3C338 in order to study its strong flux density variability, its large scale properties and the structural variations at parsec scales (Giovannini et al. 1998).

The large-scale structure of 3C338 can be separated in two regions with very different properties: an active region, which includes the core, two symmetric
Fig. 1. VLA maps of J1835+620 at 1.4, 4.9 and 8.5 GHz, rotated clockwise on the sky by 60°. Contours are spaced by factors of 2 in brightness, with the lowest at 3 times the rms noise level. The vectors represent the polarization position angle (E-vector), with length proportional to the amount of polarization. 1″ corresponds to 4.81 Kpc.

Fig. 2. Optical observations of J1835+620: The left panel shows an R-filter image centered at the position of the radio core. The right panel shows a detail of the optical image after the application of deconvolution algorithms. The host galaxy of J1835+620 is labeled with the letter “G”.

jets and two faint hot spots at the jet ends, and a diffuse region, displaced to the south, showing a jetlike filament and low-brightness extended emission (Giovannini et al. 1998) (Fig. 3). If the radio core stopped or decreased its activity at some time, it could have left a steep-spectrum aged radio jet behind
Burns et al. (1983) suggested two possible explanations for the existence of two separated regions in this peculiar source: (1) the ram pressure of a highly asymmetric cooling flow onto the cD galaxy or (2) the motion of the radio core within the cD galaxy. Alternatively, the relic emission could have been produced by past activity in one of the other nuclei in the cD galaxy. However, the relic and the new emission being quite parallel and the curvature of the relic filament in agreement with Burns et al. suggestions make this interpretation less attractive.

The radio structure of the small region is similar to that of extended FR II radio galaxies but on a much smaller scale, similar to the high-power medium-sized symmetric objects found at high redshift (Readhead et al. 1996). At parsec scales, 3C338 has an unusual structure consisting of a compact core and two symmetric jets, with moving components in both directions (Fig. 4).
4 Conclusions

We present observational results on two very different radio galaxies, the giant FR II J1835+620 and the FR I 3C338, both with radio structures showing evidence of distinct phases of activity during their lifetimes. If the activity is intimately related to the accretion of matter onto a massive object, the vanishing or diminution of accretion would lead a former radio source to a “dormant” or hibernation phase. Such a picture is supported by the increasing number of massive dark objects detected in inactive galaxies (Kormendy & Richstone 1995). Interaction and merging with neighboring galaxies can trigger the activity, and eventually produce a transition from a dormant to an active-core phase (Stockton & MacKenty 1983, Bahcall et al. 1997). We note that J1835+620 and 3C338 have both optical counterparts with nearby companions, with signs of mutual interaction (Figs. 2, 3), supporting the previous scenario.

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