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Recurrent activity in radio galaxies

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Abstract. One of the outstanding issues concerning extragalactic radio sources is the total duration of their active phase and the possible existence of duty cycles of nuclear activity. A duty cycle can be recognised if there is a mechanism which preserves the information of a past activity for a sufficiently long time after a new activity has started up. From the study of relic radio galaxies we know that radio lobes can remain visible for a relatively long time after the central activity switched off. If a new cycle of activity starts before the radio lobes created during a former activity period have faded, we can in principle recognise this by the observations of a young radio source embedded in an old relic structure.

Key words. radio continuum: galaxies – galaxies: active

The idea of recurrent activity in radio galaxies (RGs) was first inherent in the models suggested for sources with 'X-shaped' radio morphologies (e.g. Rottmann 2001). The 'X-shaped' RGs exhibit large, symmetric, and low-luminosity extrusions of radio plasma that extend at some angle from the nucleus to distances comparable to, or exceeding, the length of the active radio lobes. Several scenarios have been suggested for the formation of this kind of RGs, e.g. back-flow of radio plasma from the active lobes, conical precession of the jets and reorientation of the jet axis. The present observations favour the third scenario proposed by Dennett-Thorpe et al. (2002).

Another class of restarted radio sources represent the so-called double-double radio galaxies (DDRGs; Schoenmakers et al. 2000). A DDRG is defined as consisting of two unequally sized, two-sided, double-lobed, edge-brightened radio sources. The two pairs of lobes are well aligned and apparently hosted by the same galaxy. DDRGs are believed to provide evidence for a brief (few Myr) interruption of the jet activity in AGNs. Liu et al. (2003) described a formation scenario for DDRGs which assumes that such objects are remnants of supermassive binary black holes mergers. During the merger event, the inner accretion disc disappears which leads to an interruption of jet formation. When the outer accretion disc slowly refills the inner one, jet formation restarts and a second pair of lobes is formed. This model predicts that the rate of DDRGs among other extragalactic radio

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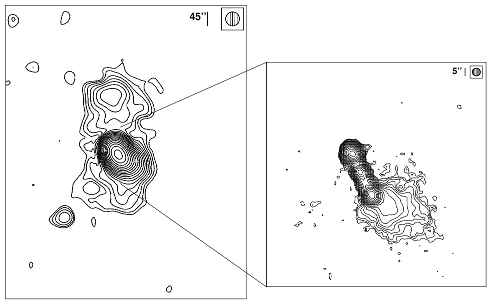

Fig. 1. Example of a RG with recurrent activity. **right panel:** 1.4-GHz map of a Cen A-type radio source from the NVSS survey (Condon et al. 1998) and **left panel:** FIRST survey (Becker et al. 1995).

sources is very small (~1%). The young beam of new activity propagates into the cocoon formed in the past activity phase. The ambient medium is, therefore, not intergalactic thermal plasma but synchrotron gas whose density is lower than that of the Intergalactic Medium (IGM). The advance speed of the inner lobes should be higher than the speed of the older lobes which expand in a denser IGM. However, Kaiser et al. (2000) argue that the typical timescale of central activity interruption ($\sim 10^6$ yr) allows for sufficient entrainment of warm clouds ($\sim 10^4$ K) of the ambient medium into the older hot ($\sim 10^7$ K) cocoon plasma and this raises the thermal density to levels adequate for the formation of hot spots at the ends of the young jets.

The third group of sources with repeated activity contain objects with radio morphologies similar to that of Cen A or Vir A. Cen A shows structures ranging over a factor of 10^8 in size. Major components of the radio source are the giant diffuse outer lobes with an angular diameter of about 10°. Then, there is the 30′ middle lobe and the inner lobes of 6′ in extent. In the centre of the source there is a compact core and jets. The different components originate from different activity epochs. The largest structures are the oldest and the smallest ones are the youngest. An example of this type of RGs is shown in Fig 1.

It is clear that the phenomenon of recurrent activity in RGs is still open for further research. Detailed studies of the DDRGs are of key importance to learn more about duty cycles of AGNs and how these affect the evolution of extragalactic radio sources in general. In the not too far future, the Low Frequency Array (LOFAR; Röttgering 2001) with high sensitivity and good angular resolution will form an excellent tool to search for recurrent activity in RGs.

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