HOW DO RADIO-LOUD AGNs ACTUALLY FADE OUT?

Dorota Przepiórka, Andrzej Marecki

Nicolaus Copernicus University
Toruń, Poland

Abstract

We analysed seven objects - 2 quasars and 5 radio galaxies - having one lobe with, and one without a hot spot, the latter being, therefore, a relic lobe. We claim that what we observe here is an ongoing fading phase of the whole AGN, while the difference in the lobes' morphologies is caused by the orientation and light travel-time effects. We tentatively propose two scenarios of fading mechanism of AGNs.

Introduction

According to a very well-established paradigm, the large-scale radio structures of a radio-loud AGN, i.e. the lobes, are powered by jets launched in the vicinity of the supermassive black hole. In particular, the existence of hot spots at the edges of the lobes is the evidence that the energy is currently transported by the jets.

Parallel to that, the immediate observable signature of the accretion, which is the primary cause of the activity in galaxies, is the presence of emission lines and a UV-excess in the in optical spectrum. This is characteristic mainly for quasars. On the other hand, in some optical objects identified with radio sources, we can observe only narrow emission lines and no UV-excess (Figs. 1,2.). This, in turn, is typical for double-lobed radio sources devoid of hot spots at their extremes. It could be that this kind of presently inactive galaxies are former AGNs and the radio structures are relics of their past activity.

However, we can also observe a class of radio sources with mixed types of lobes, namely with one lobe being still active, i.e. with the hot spot at its edge still present, and the other one fading, i.e. lacking a hot spot.

Analysis

A sample of 156 radio sources, both quasars and radio galaxies, constructed with the use of NVSS and FIRST radio catalogues and SDSS optical catalogue was analysed. Seven objects with one active and one fading lobe were found among them. Two of them are quasars and the remaining five are galaxies. The spectra of quasars have broad emission lines and a UV-excess. (Fig. 3.), whereas in the spectra of galaxies (Figs. 1 and 2), we can sometimes observe narrow emission lines and no UV-excess.

Two possible scenarios of the fading process in AGNs seem plausible. The first one could be applied for galaxies and is as follows:

- the activity in the accretion disk ceases first. This breaks the production of the jets.
- Shortly after that, broad lines as well as the UV-excess in optical spectra disappear.
- The narrow emission lines (produced in a much more distant and larger region) disappear later.
- Eventually, the lobes begin to fade. They enter the so-called "coasting phase". The hot spots disappear.
- If the radio source does not lie in the sky plane the light travel-time effect makes the lobes appear different as they - and particularly their hot spots - are at different stages of fade-out.

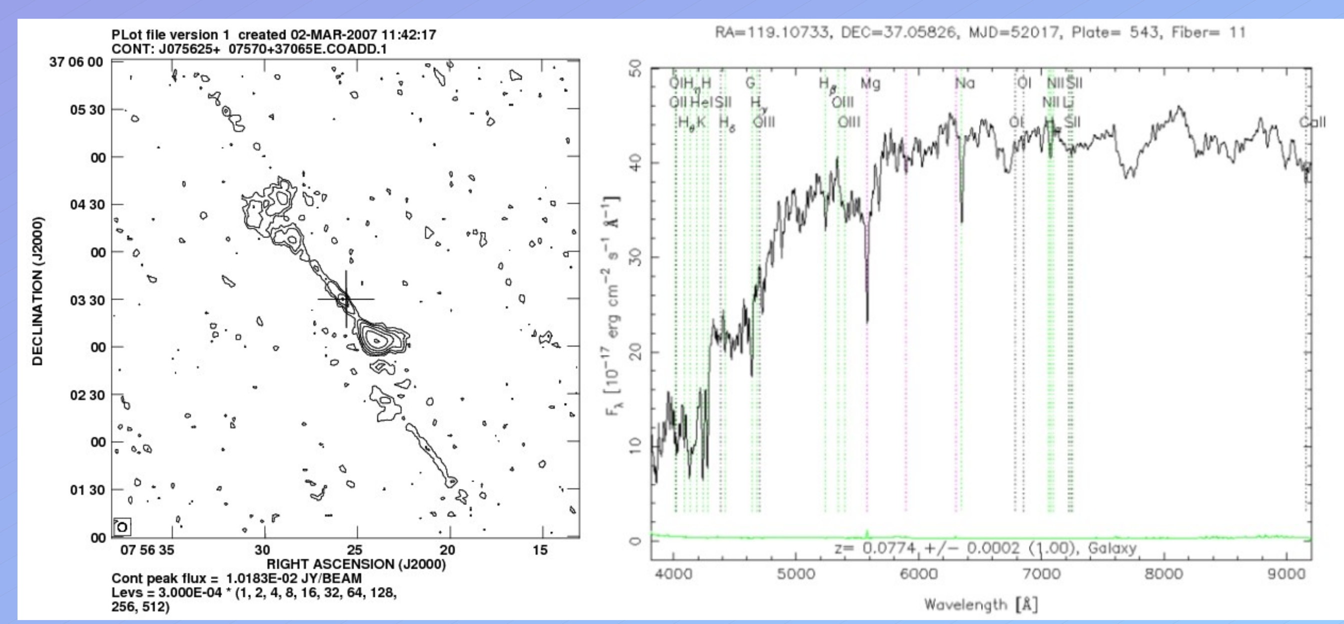

Fig.1. Galaxy J075625+370330. The north-eastern lobe is fading. The optical continuum goes down towards shorter wavelengths and there are no strong emission lines. Thus, optically, this is a normal (=inactive) galaxy but in the radio it is a formerly active galaxy.

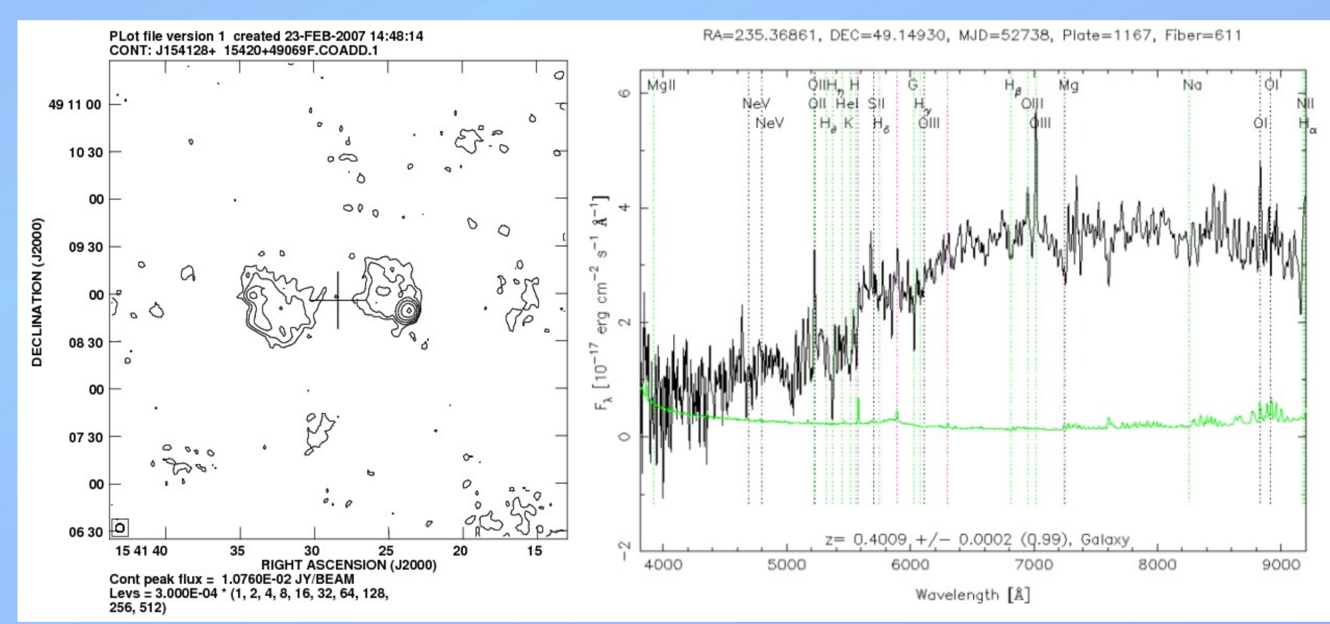

Fig.2. Galaxy J154128+490856. The radio core is invisible in the contour map. The only bright radio feature is a hot spot at the edge of the western lobe. There are narrow emission lines in optical spectra.

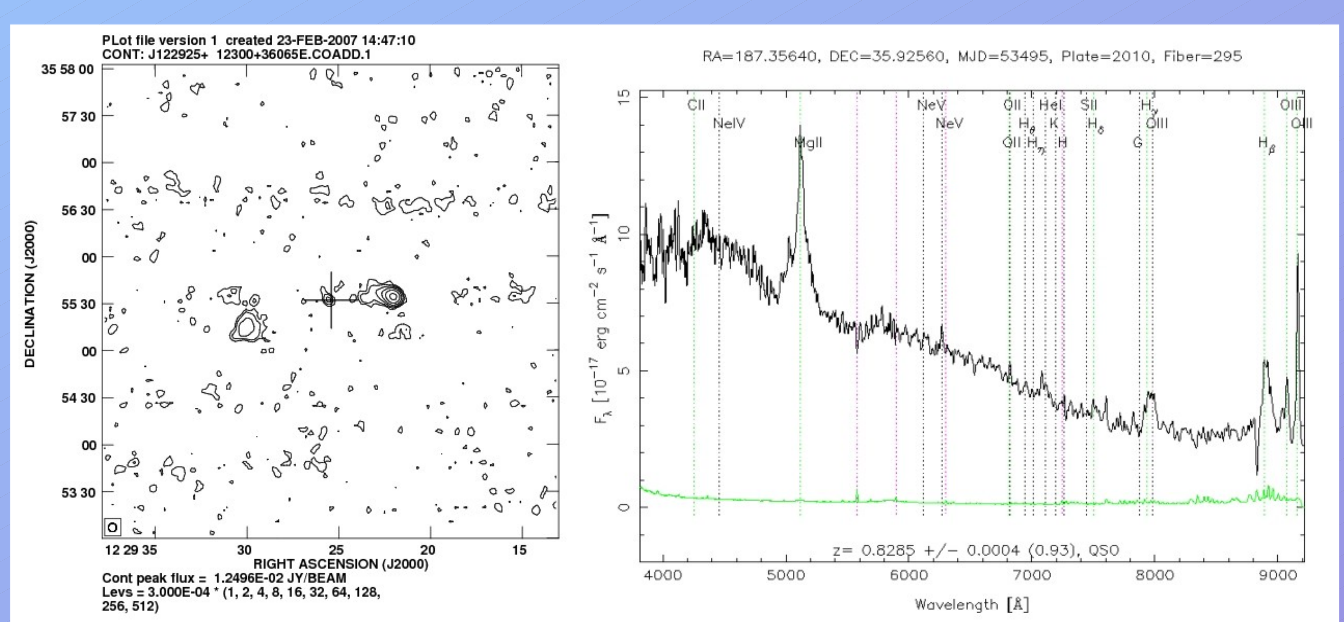

Fig.3. Quasar J122925+355532. Here, we have a typical AGN spectrum with broad emission lines and a UV-excess but only one lobe (the western one) is edge-brightened while the other one is fading out.

The above scenario cannot explain though why quasars, i.e. still active galaxies, can have one coasting lobe as the presence of such kind of lobes means the activity must have switched off. Thus, we propose a second scenario that could mainly be applied to quasars but possibly also to radio galaxies. In radio domain, it is compatible with the first scenario. As for the optical properties, the key difference is that because the UV-excess and the emission lines can be observed in quasars anyway, the accretion disk must still be present and be hot. However, for some reasons it is no longer able to produce jets and so the radio structures must fade. Such a switch to the radio-quiet type of activity of the disk might be caused by thermal-viscous instabilities (Hatziminaoglou et al., 2001). Again, the orientation effects can be responsible for the lobe asymmetry. When applying this scenario to galaxies, we have to assume that the object lies relatively close to the sky plane and so the radiation from the accretion disk and the broad-line region is efficiently blocked by the dusty torus.

Conclusions

We tentatively propose two scenarios of fading mechanism of AGNs. Although the first scenario seems to be quite plausible for a number of AGN classes, the second scenario is more flexible as it can be applied to both quasars and galaxies. It could also be a support for the thermal-viscous instabilities mechanism, the latter appearing responsible not only for the process of episodic (recurrent?) activity as a whole but also for switching between radio-loud and radio-quiet type of an AGN.

Reference

Hatziminaoglou, E., Siemiginowska, A. & Elvis, M. (2001). Accretion Disk Instabilities, Cold Dark Matter Models, and Their Role in Quasar Evolution. ApJ, 547:90-98.