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Deducing the orbit of the radio galaxy 3C 129

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Abstract.
We have obtained new optical spectra of the radio galaxy 3C 129 and the giant galaxy close to it. From these spectra we deduce a relative radial velocity of 710 km s^{-1} between the two galaxies. Using the orbit calculations of Byrd & Valtonen (1978) and the new observations we obtain a new value, $3.3 \times 10^{14}\,M_{\odot}$, for the mass of the system.

1. Introduction

The radio galaxy 3C 129 possesses a long radio tail shaped approximately like a segment of an ellipse curving around a nearby giant galaxy (Fig. 1). Byrd & Valtonen (1978) used the segment to deduce the 3C 129 orbit around the giant galaxy, with and without tail buoyancy. The chief difficulty was the unknown redshift of the giant galaxy. We have now obtained a redshift for the giant galaxy with the Nordic Optical Telescope.

2. New observations and analysis

The spectra of the 3C 129 host galaxy (previous redshift z = 0.0208; Spinrad 1975) and the nearby giant galaxy were obtained with the ALFOSC instrument at the Nordic Optical Telescope (NOT). A 1.2 arcsec wide slit aligned with the centers of the 3C 129 host galaxy and the giant galaxy was used. The total exposure time was 7200 seconds. The spectra were carefully wavelength calibrated to remove any distortions caused by instrument optics and flexure. The final flux-calibrated spectra are shown in Fig. 2. The spectra show both 3C 129 and the giant galaxy to be ellipticals at z = 0.0204 ± 0.0003 and z = 0.0180 ± 0.0001, respectively.

Byrd & Valtonen (1978) fitted the orbit of 3C 129 to a simple model in which both galaxies were point masses. This model gives a radial velocity difference of v_{old} = 231 $\mathrm{km\,s^{-1}}$ between the primary and the secondary if the mass of the

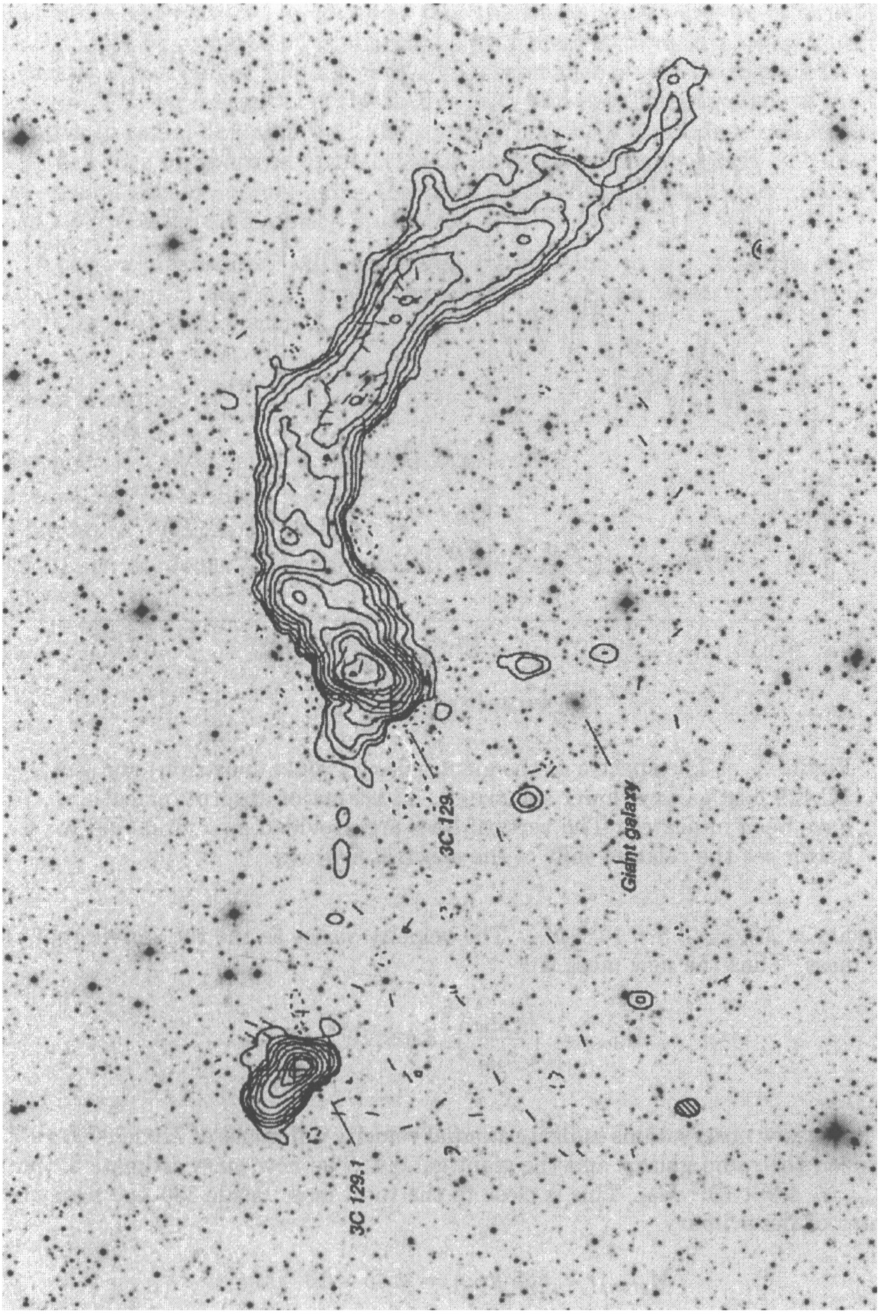

Figure 1. The 608 MHz radio contours of 3C 129 and 3C 129.1 from Jägers et al. (1987) overlaid on top of a POSS Digitized Sky Survey image. The giant galaxy is also identified. Field size is 36' × 24'.

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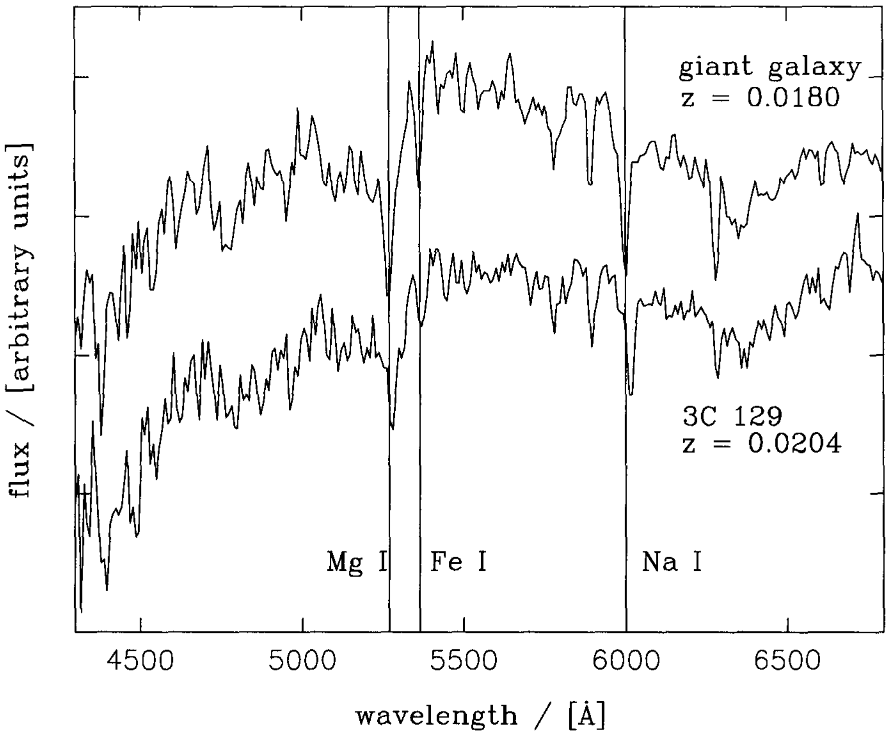

Figure 2. The spectra of the giant galaxy (upper spectrum) and the 3C 129 host galaxy (lower spectrum). Three major absorption features have been indicated. The vertical lines are provided as a visual aid to better see the relative shift of the spectral features.

primary is $M_{old} = 3.5 \times 10^{13}\ M_{\odot}$. The velocity varies as the the square root of the mass. Thus the new mass is

$$M_{new} = \left(\frac{v_{new}}{v_{old}}\right)^2 3.5 \times 10^{13}\ M_{\odot}\ .$$

Our new observations indicate a radial velocity difference of 710 ± 100 km s^{-1} between the radio galaxy and the giant galaxy. The new mass estimate is thus $M_{new} = 3.3 \times 10^{14}\ M_{\odot}$. This is close to the total mass inside 835 kpc from the center of the primary

$$M_{grav}(r < 835\ \mathrm{kpc}) = 4.45 \times 10^{14}\ M_{\odot}$$

determined from X-ray observations (White, Jones & Forman 1998).

We are currently redoing the orbital fit by Byrd & Valtonen (1978) using more realistic mass distributions (e.g. an isothermal sphere). A process that also needs to be included in the models is the effect of buoyancy on the tail.

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The radio observations do not show that the the tail is a pure arc of an ellipse as it should be if buoyancy is absent. Instead there is an upturn away from the primary at the end of the tail (Fig. 1). The challenge will be to produce this upturn. The varying speed of the radio galaxy and the changing angle of the tail relative to radial direction from the primary may help to produce this feature.

Once we have deduced the orbit of the head-tail radio galaxy 3C 129, we can assign ages to points along the tail. This will help us to understand the plasma processes taking place in the tail.

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