THE LARGE- AND SMALL-SCALE STRUCTURES OF 3C 293

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ABSTRACT

The radio galaxy 3C 293 has been mapped with the VLA at 1.465 and 15.035 GHz with resolutions of 6″ and 0.″2, respectively, and with the Multi-Element Radio Linked Interferometer Network (MERLIN) at 1.666 GHz with a resolution of 0.″25. The VLA 1.465-GHz map shows that the source has a two-sided Z-shaped structure whose physical association with the galaxy VV 5-33-12 is now clear. The source is unusual in that it is dominated by a steep-spectrum extended core. The core is resolved by the MERLIN 1.666-GHz and VLA 15.035-GHz observations into an inner two-sided structure within 1 kpc of the center of VV 5-33-12, and curved bridges of emission linking this structure to the large-scale emission. If equipartition conditions apply in the core, its straight radio spectrum between 408 MHz and 15 GHz implies that its age since last particle replenishment is less than 5% of the light travel time to the outer radio lobes. The major axis of the core lies 35° from the major axes of the emission bridges that make up the bar of the large-scale Z structure, and 60° from the minor axis of VV 5-33-12. We discuss precessional and buoyant-refraction models for these misalignments. Models based on perturbations of the axis of the primary collimator in 3C 293 appear unattractive, since the galaxy is exceptionally isolated and the required perturbation time scale is short. Models based on continuous-jet refraction in a dense high-temperature core within VV 5-33-12 are plausible, since the required misalignments can be produced by anisotropic pressure gradients in an atmosphere of modest mass and x-ray luminosity. These models may be tested with x-ray observations of the core of VV 5-33-12. If validated, they could explain the tendency of large-scale radio sources to form *near* the minor axes of their associated galaxies.

I. INTRODUCTION

The radio source 3C 293 (= 1350+316) is identified (Wyndham 1965) with the $m_V = 14^m.3$ E6 galaxy VV 5-33-12, whose redshift is 0.0452 (Sandage 1966; Burbidge 1967). The galaxy has several optical and radio peculiarities. An unusually high fraction ($\sim$ 80%) of its radio emission arises in a steep-spectrum ($\alpha \sim 0.7$, $S_\nu \propto \nu^{-\alpha}$) core component several arcseconds in extent around the nucleus of the galaxy (Bridle and Fomalont 1978, hereafter referred to as BF; Argue, Riley, and Pooley 1978, hereafter referred to as ARP). Most of the remaining emission is from a weak extended lobe whose peak is 85″ (52 kpc, $H_0 = 100$ km s^{-1} Mpc^{-1}) northwest of VV 5-33-12. Neither the displacement of the lobe from the galaxy nor the elongation of the lobe itself aligns with the symmetry axes of the extended radio core or of the optical galaxy. The physical association between the extended lobe and the core source has therefore been in some doubt. Reich *et al.* (1980) report weak sources 14′ (510 kpc) and 27′ (980 kpc) from the radio core in approximately the same position angle as the lobe, but their association with the rest of 3C 293 is speculative.

VV 5-33-12 is unusually flat for a radio galaxy and has a complex internal structure (ARP). It has been suggested as a possible Sb by Sandage (1966) and as a possible S0 by Colla *et al.* (1975). Some of the apparent optical complexity is due to dust (Wyndham 1966; Battinisti *et al.* 1980).

The existence of a weak radio bridge between VV 5-33-12 and the extended lobe has been tentatively reported by several observers (Colla *et al.* 1975; Högbom and Carlsson 1974; BF; ARP). The 20-cm map by Högbom and Carlsson in particular suggested that such a bridge might be appreciably linearly polarized. As the existence of an emission bridge would confirm the relationship of the lobe to VV 5-33-12, and its shape could give clues to the origin of the various misalignments present in 3C 293, we made sensitive observations of the source with the VLA (Thompson *et al.* 1980) at 1.465 and 15.04 GHz and with MERLIN (Davies *et al.* 1980) at 1.666 GHz to map both the large- and small-scale structures.

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