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A Spectral Analysis of 3C 67 and 3C 190

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Abstract. Using new high resolution VLA and VLBA data and existing MERLIN data of 3C 67 and 3C 190, we find both sources have a complex spectral structure similar to larger Fanaroff-Riley type II sources. Our analysis of 3C 190 predicts either an unusually steep injection index of -0.8 and a young age, or a superposition of different age spectral components.

1. Introduction

We analyze the synchrotron spectrum of two compact steep spectrum sources (CSSs), 3C 67 and 3C 190, in order to address the question of the age of CSSs, and to compare their spectral structure to larger radio sources. In this paper we apply innovative methods which we have developed and used on larger radio sources (Katz-Stone et al. 1993; Katz-Stone 1995; Katz-Stone & Rudnick 1997a; Katz-Stone & Rudnick 1997b). "Spectral tomography" is used to isolate overlapping features; "color-color diagrams" are used to determine the shape of the synchrotron spectrum.

Both sources were previously observed with MERLIN at λ 18 cm. We observed them with the VLA (λ 3.6 cm) and the southwest portion of the VLBA (λ 90 cm). Unfortunately, 3C 67 was within 15 degrees of the sun corrupting the phase information. Because of this and in the interest of brevity, the rest of this discussion will focus upon 3C 190.

2. Synchrotron Spectrum and Aging

Figure 1 identifies 4 major components for 3C 190. We use a color-color diagram to analyze the spectral shape of these four components (Figure 1; see also: Katz-Stone & Rudnick 1997a). The location of the core is indicative of a slightly inverted, concave down spectrum. The placement of components A, B, and D indicates that they have concave down spectra. The location of D implies that its spectrum is more curved than A or B and is likely to be synchrotron self-absorbed. Correcting for this, we find that a standard aging model (Jaffe & Perola 1973) fits components A, B, and D if we allow the injection spectral index to be -0.8 and assuming a single, homogeneous electron population. Using this result, we find the average age of these three components is approximately 50 kyr. Thus 3C 190 appears to be quite young. This result is a direct consequence of invoking a steep injection index which any homogeneous standard aging model would require to fit these data.

If CSSs are found to have steep injection indices in general, it might suggest that they are either a different type of object entirely, or that there is an evolution of the injection index as CSSs grow into large radio sources.

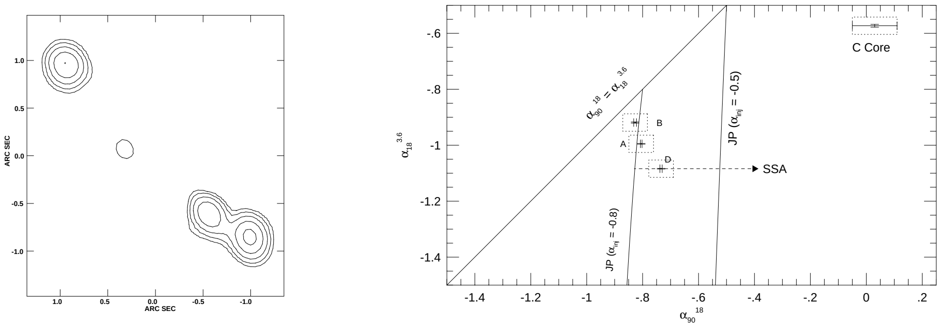

Figure 1. Left: VLBA map of 3C 190 at λ 90 cm. Components are labeled A (south) through D (North.) Right: Color-color diagram for 3C 190. Dotted line boxes represent the larger of either random errors or systematic calibration errors. The spectral indices of D are significantly (17σ) different from both A and B.

3. Inhomogeneous Spectral Components?

In Katz-Stone (1995), we introduce spectral tomography as a technique for identifying confused spectral features. Spectral tomography of both 3C 67 and 3C 190 reveal complex spectral structure (Katz-Stone & Rudnick 1997a). Therefore, it is likely that the components of 3C 190 are a mixture of spectral features.

The mixture of components can make the identification of the appropriate spectral shape complicated. For example, Tribble (1993, 1994) considered the superposition of two different age electron populations (each with an injection index of -0.5); he found that the locus of points in the color-color diagram is close to the power law line for a large range in spectral index ($\Delta\alpha_{20}^{6} \approx 2.0$). This can lead to a spuriously steep estimate for the injection index.

The shape of Tribble's spectrum depends upon the ratio of population ages, not the absolute ages, and as time passes both this ratio and the shape of the spectrum change. Therefore, to properly measure ages, it is necessary to map out and carefully model the shapes of the synchrotron spectra. Until this is done, the absolute spectral age of 3C 190 remains ambiguous.

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References

Jaffe, W. J., & Perola, G. C. 1973. *A&A*, **26**, 423–435.

Katz-Stone, D. M., Rudnick, L., & Anderson, M. C. 1993. *ApJ*, **407**, 549–555.

Katz-Stone, D. M. 1995. *Ph.D. Thesis*, University of Minnesota.

Katz-Stone, D. M., & Rudnick, L. 1997a. *ApJ*, **479**, 258–267.

Katz-Stone, D. M., & Rudnick, L. 1997b. *ApJ*, **488**, 146–154.

Tribble, P. C. 1993. *MNRAS*, **261**, 57–62.

Tribble, P. C. 1994. *MNRAS*, submitted.