THE LOW FREQUENCY VARIABILITY OF EXTRAGALACTIC RADIO SOURCES

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ABSTRACT. The spectral evolution between 0.3 and 15 GHz of the extragalactic radio sources 0235+164 and 1611+343 (DA406) is presented. The data show two very different forms of behavior. For 0235+164 the variations over the entire frequency range are correlated and consistent with being intrinsic to the source, whereas for DA406 an extrinsic cause for the variability seems probable.

1. INTRODUCTION

Variability at low frequencies ($\nu < 1$ GHz) of extragalactic radio sources has for some time been the subject of several investigations. The main point to be clarified is whether observed variations in a given source are intrinsic and simply a continuation of the high frequency activity, or due to a propagation effect either in the material surrounding the source or in our galaxy.

Several recent results suggest that for the majority of sources the variability is extrinsic (Fanti et al. 1983; Dennison et al. 1984; Altschuler et al. 1984; Padrielli et al. 1986), possibly the result of refraction from electron density fluctuations in the interstellar medium (Rickett et al. 1984; Shapirovskaya 1982).

2. RESULTS

The low-frequency data for the sources 0235+164 (BL Lac object, z=0.94 (Cohen et al. 1986), b=-39); and 1611+343 (QSO, z=1.40, b=46) are part of those obtained in a program started in 1980 to investigate the multifrequency behavior of extragalactic radio sources chosen from

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complete samples searched for variability at 318 MHz by Condon et al. (1979), and Dennison et al. (1981). The bi-monthly measurements of 30 sources were made with the NAIC Arecibo 305 m radiotelescope at 318, 430, and 606 MHz, and with the NRAO Green Bank 91 m radiotelescope at 880 and 1400 MHz. Details may be found in Altschuler et al. (1984).

To this data we have added high-frequency measurements made with the University of Michigan 26 m radiotelescope at 4.8, 8.0, and 14.5 GHz from the program of Aller et al. (1985). The combined data provide an opportunity to investigate the variability of radio sources at 8 frequencies from 0.3 to 15 GHz.

The resulting spectra shown in figure 1 cover the period of a high-frequency outburst in 0235+164 and a low-frequency outburst in DA406.

3. DISCUSSION

The very different spectral behavior of these two sources is striking. For 0235+164 the high-frequency outburst peaking about 1982.14 is seen to peak at lower frequencies at progressively later times as indicated by the circled numbers. The amplitude of the variations increases roughly as $\nu^{0.4}$ as indicated by the solid arrow, in accord with the empirical result obtained by Andrew et al. (1978) from an investigation of the variability of radio sources at high frequencies. The correlation of high and low-frequency activity in this source indicates that the variability at all frequencies is due to the same cause. If intrinsic, relativistic bulk motion of the source with $\gamma \sim 15$ is required (O'Dell et al. 1985) in order that the brightness temperature derived from the variability timescale not exceed 10^{12} K.

The high-frequency data for DA406 were taken from the literature without regard for the precise epoch of observation and illustrate the long term stability of its flux density. The low-frequency outburst is the second one observed, the first one peaking in 1977 showing a similar light curve (Cotton and Spangler 1979; Padrielli et al. 1986). There is no significant difference in the light curves observed at 318, 430, and 606 MHz, the variations being simultaneous to within our sampling uncertainty and of equal amplitude. A preliminary analysis of the light curves of other variable sources in our program also shows no strong wavelength dependence of the low-frequency variability amplitude, although the amplitude does decrease at 880 and 1400 MHz.

Of note is the fact that the low-frequency flux of DA406 at the maximum (spectrum 3) lies close to an extrapolation of the high-frequency spectrum and that the maximum low-frequency flux was about the same in 1977 and 1982. This behavior is suggestive of absorption as the cause for variability (Marscher 1979), a possibility which should be further investigated as an alternate to scattering models.

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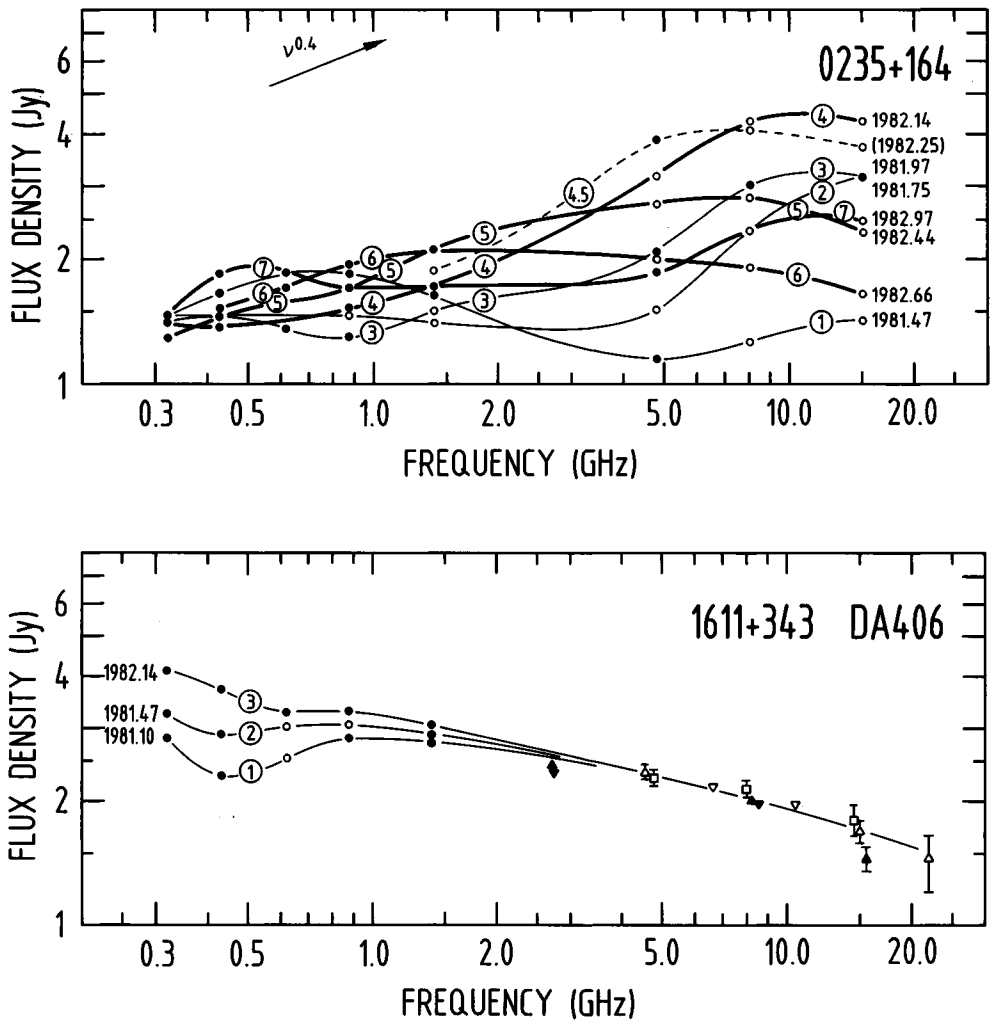

Figure 1. The multi-epoch spectra of 0235+164 and 1611+343 (DA406). A hand drawn curve joins the points for each epoch and is labeled by circled numbers. The filled circles are simultaneous measurements (to within a few days), whereas the unfilled circles are a linear interpolation between dates adjacent to the epoch of the spectrum, usually separated by less than two weeks. The high-frequency data is from Aller et al. (1985). Additional high frequency data for DA406 is as follows: □ 1982-83 average from Aller et al. 1985; ▼ 1972-75 average from Altschuler and Wardle 1976; △ 1977 data from Owen et al. 1978; ▲ 1977-78 average from Cotton and Spangler 1979; ▽ 1970-76 average from Andrew et al. 1978.

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