Bull. Astr. Soc. India (1989) **16**, 183–191

Decametric radio spectra of some galaxies in clusters

K. R. Subramanian[1] and Ch. V. Sastry[2]
[1]*Indian Institute of Astrophysics, Bangalore 560 034*
[2]*Raman Research Institute, Bangalore 560 080*

Received 1988 May 30; accepted 1988 August 31

Abstract. Observations of 12 radio sources identified with clusters of galaxies were made 1983–84 with the decameter wave radio telescope at Gauribidanur. The measured flux densities at 34.5 MHz are combined with other low frequency measurements to derive their radio spectra. It is found that the average spectral index in the frequency range 34.5 MHz to 408 MHz is —1.32, much steeper than the average of extragalactic sources.

Key words : Cluster of galaxies—radio astronomy

1. Introduction

Extensive radio observations of sources associated with clusters of galaxies have shown that these sources tend to have steep spectra compared to other types of extragalactic sources. The steep spectrum of a cluster source is generally believed to be due to synchrotron losses of a radio source confined by a hot intra-cluster gas. This suggestion is essentially based on observations of cluster radio sources from centimetric to metric wavelengths. We attempt here to extend the spectra of some of these sources to decametric wavelengths with a view to determining the nature of the spectrum at such long wavelengths.

2. Observations

The observations reported here were made at 34.5 MHz with the decameter wave radio telescope at Gauribidanur (Long : 77° 27′ 07″ E and Lat : 13° 26′ 12″ N). The telescope consists of two broadband arranged in the form of a *T* and the outputs of the two arrays are correlated to produce a beam whose half-power beam widths are 34′ × 48′ sec (dec—14° .1). The effective area is approximately 250λ^2. It is possible to observe a given region of the sky either using a single beam or in a beam scanning mode wherein the beam is shifted rapidly to various declinations. A brief description of the electronic beam scanning system of this telescope is given by Sastry & Shevgaonkar (1983).

3. Results and discussion

We have measured the flux densities of 12 cluster radio sources at 34.5 MHz taken from the catalogue of Slee & Quinn (1979). The selection of the sources was based on the sensitivity and confusion limit of our radio telescope. These measurements were made during 1983–84 and each source was repeatedly observed until at least six to eight good records free of man-made interference and ionospheric effects were obtained. The radio source 3C 353 was used as a calibrator whose flux density at 34.5 MHz according to the scale of Kuhr *et al.* (1981) is 762 ± 34 Jy. Table 1 gives the positions of the sources and the flux densities measured by us. In figures 1*a* to 1*l* are plotted the observed flux densities at various frequencies from 10 MHz to 408 MHz for the 12 clusters. The flux densities at various

Table 1. Positions and flux densities at 34.5 MHz of cluster sources

Source name	Right ascension (1950)			Declination (1950)			Flux density at 34.5 MHz (Jy)
	H	M	S	Deg.	Min.	Sec.	
85	00	38	59.0	−09	39	23	142± 6
119	00	54	59.6	−01	39	38	75± 4
113	01	00	13.9	−22	08	27	58± 7
400	02	55	04.5	05	50	31	104± 2
496	04	31	57.3	−13	16	42	57± 3
644	08	15	48.3	−07	56	16	26± 3
1251	12	51	58.8	−20	57	26	78± 4
1367	11	42	31.4	−29	53	30	148±11
1518	15	19	23.0	07	52	09	285±14
1795	13	46	33.9	26	50	12	44± 2
2029	15	08	26.9	05	55	44	62± 7
2440	22	21	15.7	−02	22	16	127±10

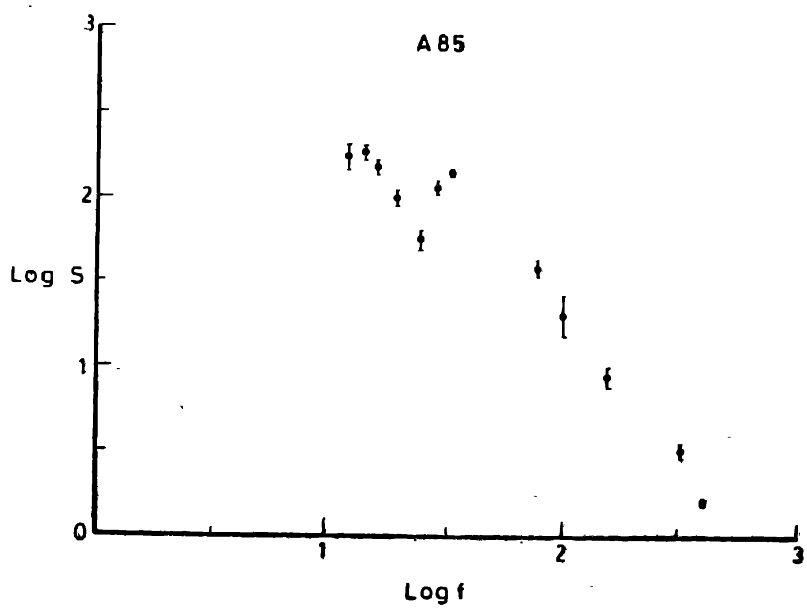

Figure 1a.

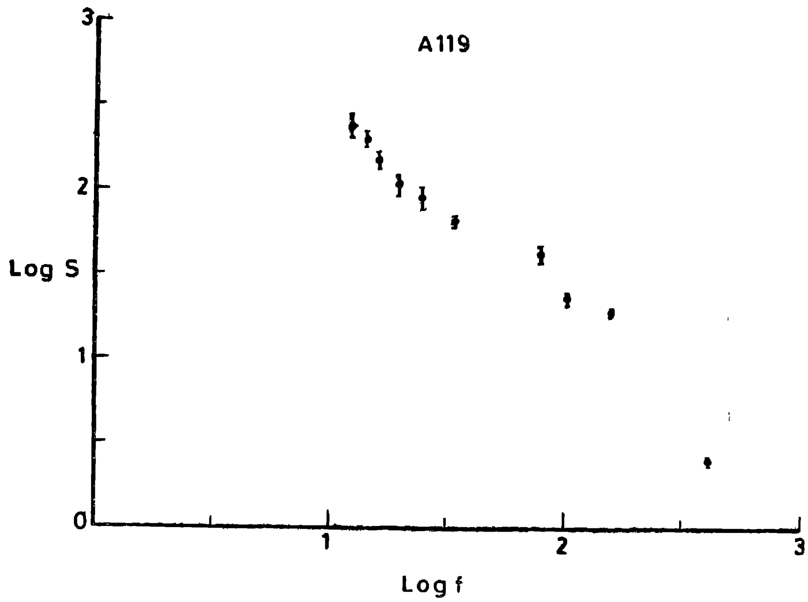

Figure 1b.

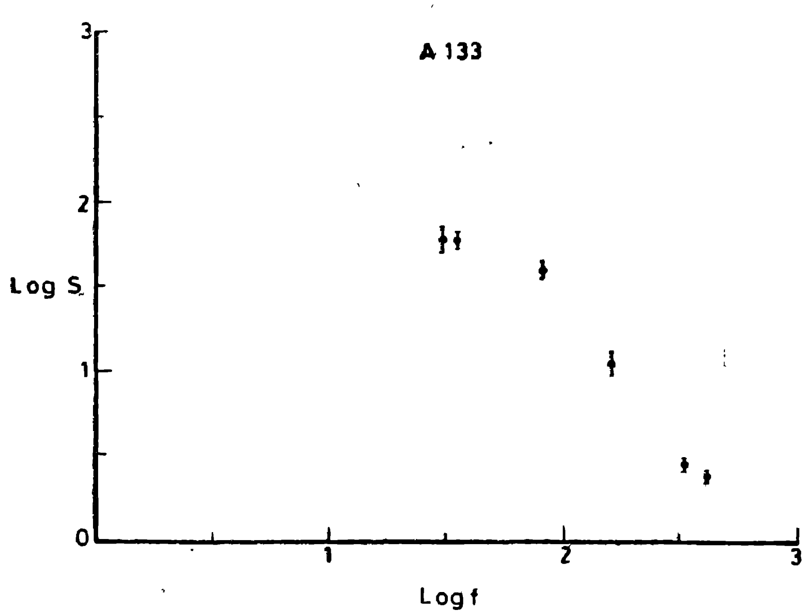

Figure 1c.

frequencies in the above range are from Braude *et al.* (1980), Finlay & Jones (1973) Slee & Quinn (1979), Dagkesamanskii, Gubanov & Slee (1982), Joshi, Kapahi & Bagchi (1986) and C. R. Subrahmanya (1988, personal communication). The spectral indices (defined as α in the expression $S \propto \nu^{\alpha}$) computed in the frequency range 12.6 MHz to 408 MHz, 34.5 MHz to 408 MHz, and the indices of Slee & Quinn (1979) at 80 MHz to 160 MHz are given in table 2. In general the spectra are straight and the spectral indices are steep upto 34.5 MHz with values ranging from —1.0 to —1.9. The average spectral index for the sources studied is —1.32, much steeper than the average spectral index of —0.75 for extragalactic objects.

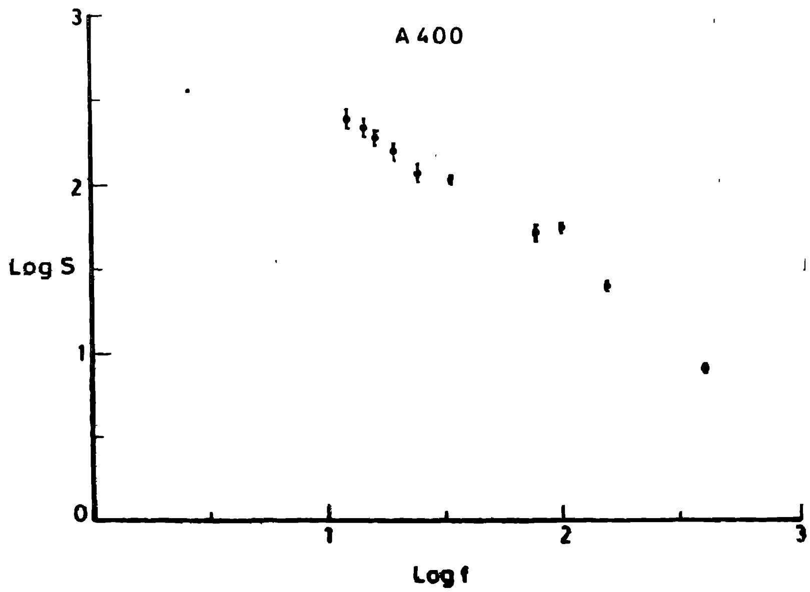

Figure 1d.

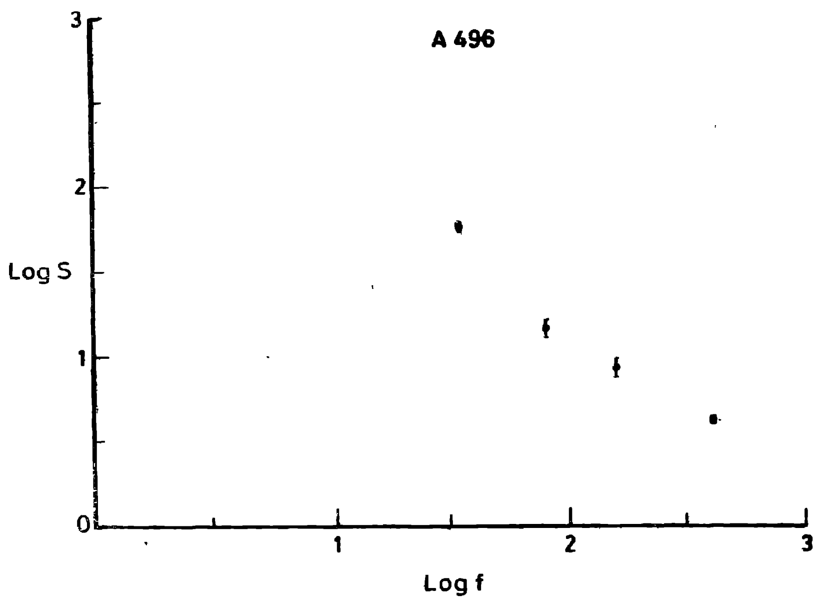

Figure 1e.

Table 2. Spectral indexes of cluster sources in various frequency ranges

Source name	12.6 MHz to 408 MHz	34.5 MHz to 408 MHz	80 MHz to 160 MHz
85	−1.56 + .01	−1.82 + .02	−1.80
119	−1.18 + .01	−1.24 + .01	−0.8
133	—	−1.41 + .03	−1.8
644	—	−1.28 + .04	−1.98
400	−1.01 + .01	−1.03 + .01	−1.0
496	—	−1.04 + .02	−0.76
1251	—	−1.20 + .2	−1.46
1367	−1.03 + .02*	−1.22 + .04†	−1.08
1518	−1.52 + .01	−1.9 + .02	−1.48
1795	—	−1.35 + .02†	−1.08
2029	−1.01 + .02	−1.056 + .03	−0.60
2440	−1.09 + .01	−1.29 + .03	−0.98

*Computed in the frequency range 12.6 MHz to 160 MHz only
†Computed in the frequency range 34.5 MHz to 160 MHz only

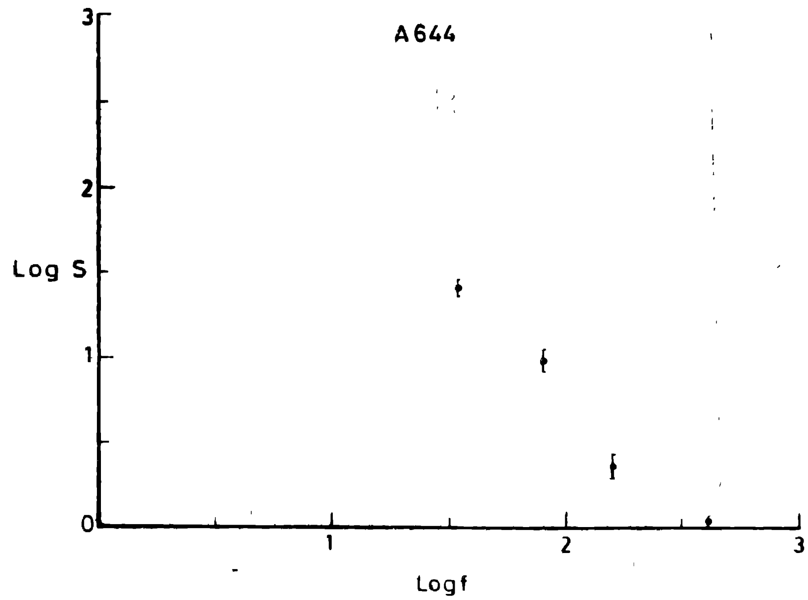

Figure 1f.

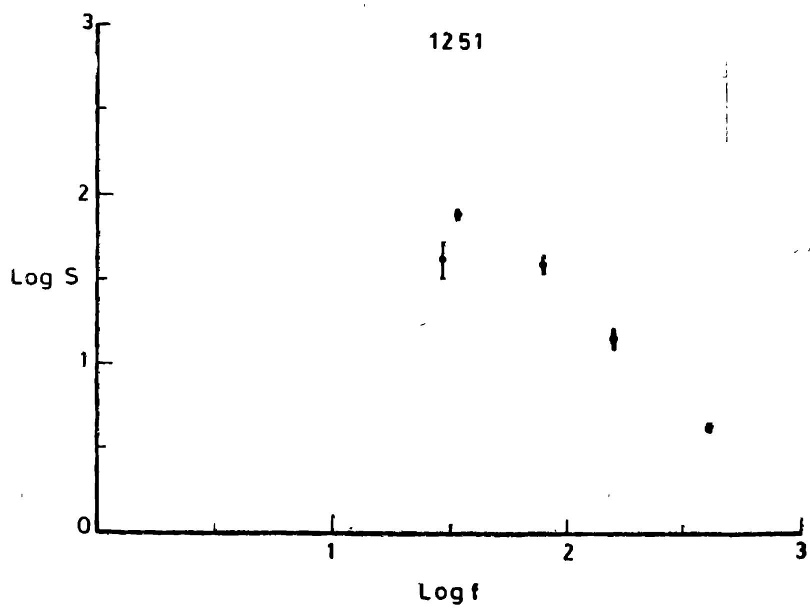

Figure 1g.

We have also extended the spectra down to 12.6 MHz wherever the data are available and found that the spectra remain steep with indices lying between —1.0 to —1.5. It should however be pointed out that the flux densities measured by Braude *et al.* (1979) for the sources A85 and A1518 at frequencies $\leqslant$ 25 MHz are significantly lower than those extrapolated from high frequency ($\geqslant$ 35 MHz) measurements. The reason for this is not clear but it would appear that the

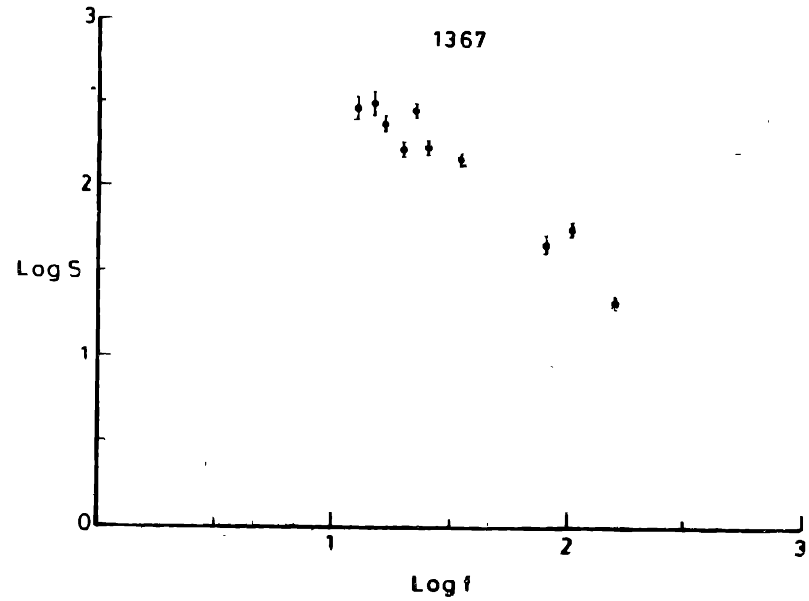

Figure 1h.

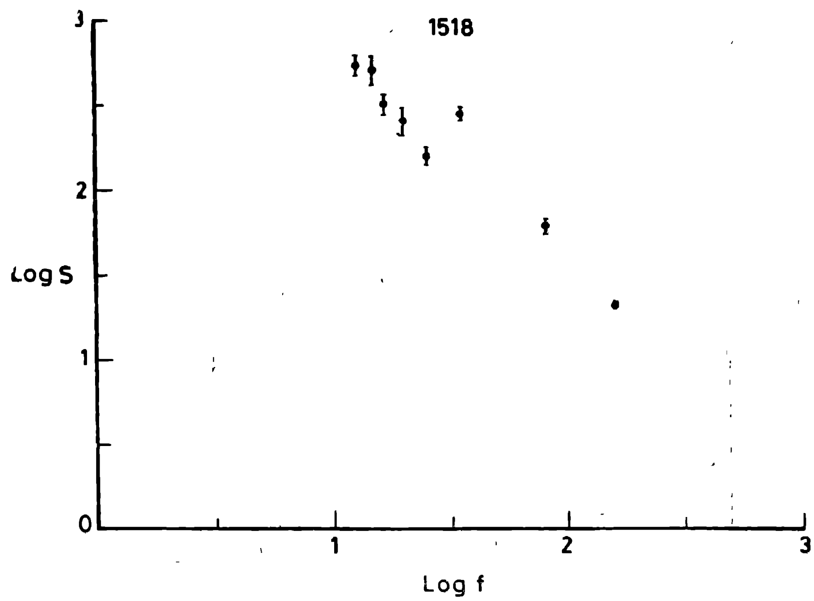

Figure 1i.

decreases are not inherent to the sources. This is because of the abrupt fall of the flux densities in a narrow frequency range ($\leqslant$ 10 MHz) as seen in figures 1*a* and 1*i*.

The steep spectral indices of radio sources in clusters are thought to be the consequence of gas in the intracluster medium. Baldwin & Scott (1973) proposed that the synchroton radio sources in clusters are confined by a hot x-ray emitting intracluster gas. If the confinement is strong and the radio source contained for a long time then synchrotron losses take place and cause the radio spectrum to