OPTICALLY QUIET QUASARS[+]

W. D. Cotton
National Radio Astronomy Observatory

1. OBSERVATIONS

The study of steep spectrum sources containing compact components has become increasingly popular as the number of papers on the topic in this volume indicates. I wish to discuss the properties of a number of steep spectrum sources which are dominated by compact components whose spectra remain steep to quite low frequencies. Most of the known sources of this type do not have optical counterparts to the limit of the Palomar Sky Survey prints and thus, with the implicit assumption that they are extragalactic, have been referred to as "Optically Quiet Quasars".

A number of the low frequency variable sources from Cotton 1976 have quite steep spectra to low frequencies and no optical counterpart to the limit of the Palomar Sky Survey. The occurrence of low frequency variations in these sources indicates the presence of compact structure which has been confirmed by VLA and VLBI observations (Cotton 1983 and Cotton et al. 1983). The observational material available for one of these sources, 2147+145, is sufficiently better than the others that in the following discussion it will be used to illustrate the properties of these sources.

The spectrum of 2147+145 is shown in Figure 1. The values plotted are from: Gower et al. 1967 (0.178 GHz); Sharp and Bash 1975 (0.365 GHz); Spangler and Cotton 1981 (0.430 GHz); Cotton 1983 (1.4, 2.7, 5.0, 8.1 and 14.9 GHz); Cotton unpublished 89.6 GHz upper limit; Owen and Puschell, private communication (upper limit 2.2 microns); upper limit in the visual due to the absence on the Palomar Sky Survey.

The spectrum of 2147+145 is steep from about 0.2 GHz up to optical frequencies. There is no evidence in this spectrum for a flat spectrum component at high frequencies as is frequently found in compact sources.

A VLBI map of 2147+145, given in Figure 2, shows a strong component and a string of knots as is frequently seen in compact quasars and

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R. Fanti et al. (eds.), VLBI and Compact Radio Sources, 53–56.

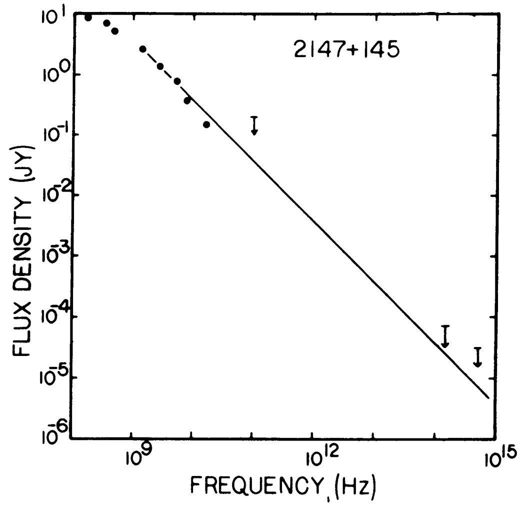

Figure 1. The spectrum of 2147+145. The straight line is an extrapolation of the 1 GHz value with a spectral index of 1.0

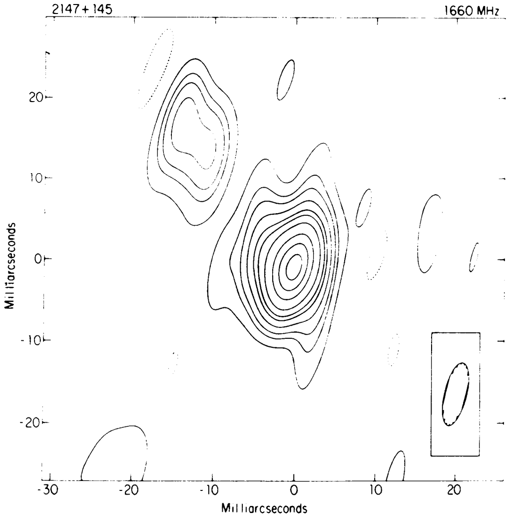

Figure 2. Structure of 2147+145 at 1.67 GHz from Cotton et al. 1983.

active galactic nuclei. The size of the strongest component is quoted by Cotton et al. 1983 as 3 milliarcseconds. Cotton 1983 gives a number of other sources with steep spectra which, on the basis of VLA observations, are dominated by compact structure.

2. INTERPRETATION

The observable properties of a synchrotron emitting source can be used to constrain the magnetic field strength. Following Terrell 1966:

$$B \propto \nu_m^{5}\, \theta^{4}\, S_m^{-2}\, (1+z)^{-1}$$

where ν_m is the turnover frequency in the spectrum, θ is the angular size of the source, S_m is the flux density at ν_m, and z is the redshift of the source. Most of the better studied sources with significant structure on the milliarcsecond scale have turnover frequencies at 1 GHz or above; i.e., have flat spectra. Since the magnetic field strength derived from the observations is proportional to the fifth power of the turnover frequency, sources such as 2147+145 must have magnetic fields which are much weaker than those in the flat spectrum sources.

A weak magnetic field has other implications about the physical conditions in the source. In particular, the density of relativistic electrons must be significantly larger than in sources with "normal" magnetic field strengths because 1) the emissivity per electron is proportional to the magnetic field strength and 2) a given energy electron radiates at a lower frequency in a weaker magnetic field. The two effects just mentioned require more electrons at higher energies to produce comparable emission to a source with a stronger magnetic field.

A high relativistic electron density in turn implies a high brightness temperature near the turnover frequency. The high brightness temperature will result in serious inverse Compton losses especially to the high energy electrons which radiate predominantly at the higher frequencies. Detailed modeling, as described in Cotton 1983, confirms the general statements made above. In order to produce a model with radio frequency properties similar to 2147+145 a very weak magnetic field and very high relativistic electron densities were required. The high peak brightness temperature produced in such a model resulted in relatively short lifetimes for electrons radiating synchrotron emission at higher frequencies and inverse Compton infrared and optical emission at levels in excess of the observational limits for 2147+145. If the relativistic electron density becomes too large the inverse Compton opacity can cause serious distortions to the synchrotron spectrum. If the strongest component of 2147+145 shown in Figure 2 still dominates the source at a few hundred megahertz then it is difficult to explain the source using a synchrotron model.

3. STEEP SPECTRUM SOURCE SURVEY

Recently a survey of steep spectrum sources was undertaken with the VLA at 5 GHz in collaboration with F. N. Owen. The results of this survey will help determine the frequency of compact, steep spectrum radio sources. The sample of sources observed were all those from the deep 5 GHz surveys of Condon and Ledden 1981 and Owen et al. 1983 with spectral indices steeper than 1.0. A preliminary analysis of the results indicate that as many as 25 percent of the 75 sources observed were dominated by a core less than about 0.2 arcseconds in size. The implication of this result is that as many as a few percent of all sources selected at 5 GHz may be dominated by steep spectrum, compact components.

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