MULTICOLOR IMAGES OF A COMPLETE $z \sim 1$ SAMPLE OF 3CR GALAXIES

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In order to look at relationships among various optical and radio properties of powerful radio galaxies at high redshifts in a systematic way, we have observed a nearly complete subsample of the Laing *et al.* (1984; henceforth LRL) revision of the 3CR extragalactic source list. Our sample comprises the 14 radio galaxies in the LRL list with $\delta < 50°$ and $0.8 < z < 1.3$. We have obtained images of 13 of the 14 galaxies (we are missing 3CR 175.1) in each of three bands. The filters used typically gave $\sim$ 200 Å (rest-frame) passbands shortward of 3700 Å and longward of 4000 Å (in order to give us a 4000 Å break index), as well as a 50 Å passband centered on the [O II] λ3727 line. The images were obtained with the Galileo/IfA TI 500 × 500 CCD system on the UH 2.2 m and CFHT 3.6 m telescopes on Mauna Kea. Absolute calibrations of the images were based on observations of Gunn-Oke spectrophotometric standard stars through the various filters. The photometry we discuss here used synthetic circular apertures closely matched for each object to those used by Lilly and Longair (1984), who give K magnitudes, at least, and sometimes J and H as well, for all objects in our sample.

The alignment of the optical continuum structure with the radio axis in high-redshift radio galaxies has been noted by Chambers *et al.* (1987) and McCarthy *et al.* (1987). We see the same correlation in our data (there is, of course, a fair degree of overlap among the samples). One should note that the concept of "optical position angle" can embrace a range of morphological properties, ranging from apparently straight-forward cases of elongated images, such as those of 3CR 324, 352, and 368, to cases of two or more discrete, but clearly associated, objects (3CR 265 and 356), to objects showing only a slight departure from circularity on our images (3CR 217, 252, 266, 267, and 280).

All of the radio galaxies in our sample show substantial [O II] λ3727 emission: the total [O II] luminosities range from ~ 5 to 70×10^{42} erg s^{-1}. Figure 1 demonstrates that there is a significant correlation between the [O II] luminosity and the low-frequency radio spectral index, indicating some connection, direct or indirect, between the radio source and the ionized gas. However, there is also a strong correlation, shown in Figure 2, between the *optical* spectral index and the global *equivalent width* of the [O II] emission. The latter correlation was first noted by Lilly and Longair (1984); the former is clearly related to the correlation between continuum color and radio spectral index found by Lilly (1988). Both serve to emphasize the intimate relationships among radio and optical properties for powerful radio galaxies at these epochs.

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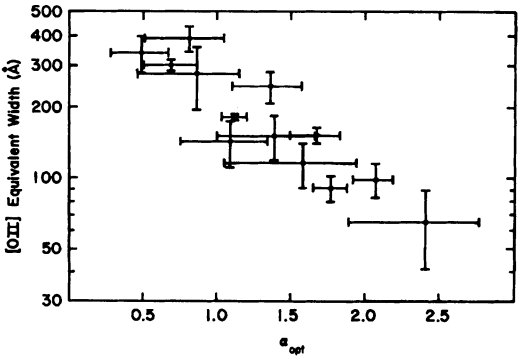

Fig. 1.—Plot of total [O II] luminosity against low-frequency radio spectral index, as given by LRL. The correlation is significant at the 98% level.

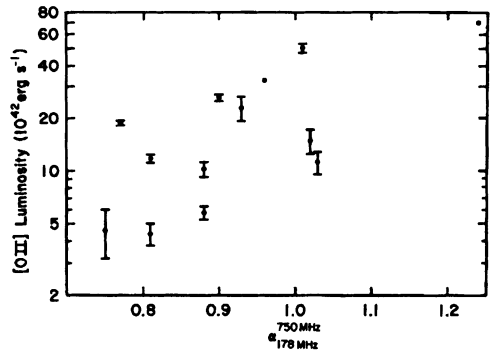

Fig. 2.—Plot of global [O II] equivalent width against optical spectral index, showing the strong correlation between these quantities. The optical spectral index defined here is the average slope in the log ν—log f_ν diagram between our long-wavelength continuum point and the K (2.2 μm) point (roughly between 4200 Å and 1 μm in the rest frame for our sample). Our rest-frame equivalent widths are systematically lower than those given by Spinrad (1982) from spectroscopic observations. Two factors may be responsible: (1) The [O II] emission tends to be clumped, and our global measurements probably take in more of the faint continuum emission; and (2) there are likely systematic effects involved in estimating continuum levels in noisy spectra of these faint galaxies.

References

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