SPECTROSCOPY OF DISTANT GALAXIES IN CLUSTERS

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Butcher and Oemler have reported that many clusters of galaxies at high redshift have enhanced populations of blue galaxies when compared to nearby clusters of similar type. Since this claim is based on broad-band colors alone, it is essential to obtain spectra of these blue objects to determine if they are actually cluster members. These spectra can also be used to provide a rough morphological classification of these objects that are too distant for detailed imaging with ground-based telescopes.

Gunn and I are conducting such a study using a low-noise CCD detector and transmission grating spectrograph (the PFUEI) at the Hale 5-m. Our first results are contained in a paper in the Dec. 15, 1982, Astrophysical Journal. Here I report on new data that has recently been obtained for one of the original Butcher-Oemler clusters, the one containing the radio galaxy 3C 295. We now have 26 good spectra of 6 red ($V-R > 1.3$) and 20 blue objects in the field studied by Butcher and Oemler. Our three principal conclusions are as follows:

(1) All six red galaxies we have studied are cluster members ($Z \approx 0.46$) and have spectra similar to present-day ellipticals or S0 galaxies.

(2) Of the 20 blue objects, 11 are not members of the cluster (foreground and background), 6 are confirmed members and 3 have no determined redshifts. Thus, instead of a $\sim 40\%$ population of blue galaxies, the true membership appears to be $\sim 20\%$. This is not an excessive fraction of blue galaxies compared to present-day clusters so the Butcher-Oemler effect is not confirmed in this first well-studied case.

(3) On the other hand, this small population of blue objects do not have the spectra of normal spiral galaxies (low-excitation emission) as is typical of the blue galaxies in nearby clusters, which are usually spirals. Instead, three of the six blue cluster members have the spectra of active galactic nuclei (high-excitation emission) in-

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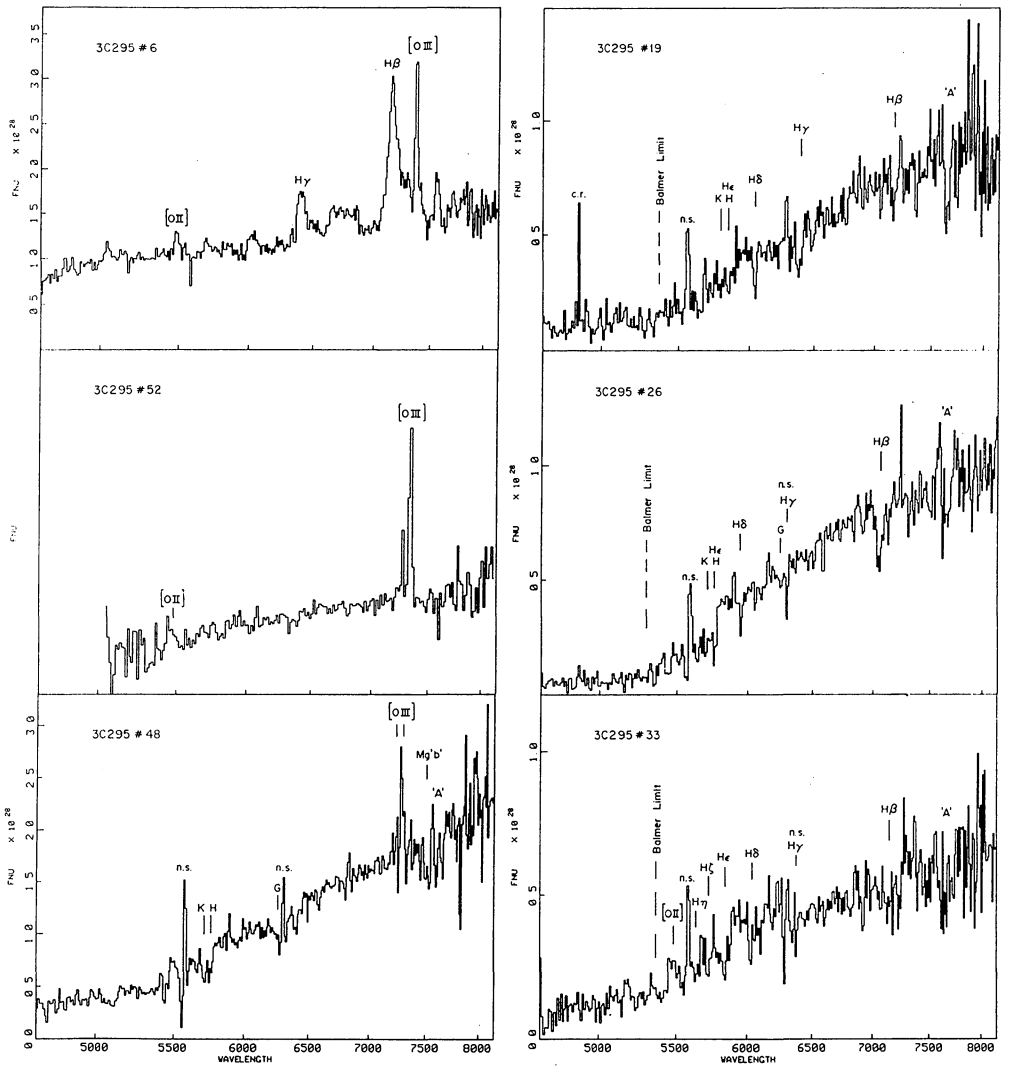

Fig. 1. The spectra of the six blue galaxies that have been found to be members of the 3C 295 cluster. The left panel shows the spectra of three galaxies with active nuclei. The right panel shows the spectra of three galaxies whose strongest features are Balmer absorption lines, probably resulting from a burst of star formation. Key: n.s. - night sky feature; 'A' - atmospheric A band.

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cluding a Seyfert 1 and a Seyfert 2. The other 3 have very strong Balmer absorption lines with no emission features, which is indicative of a strong burst of star formation $\sim 10^9$ years old. The spectra of these six active galaxies are shown in Figure 1. Both of these types of galaxies are present today but they are rare, comprising only a few percent of the population. Therefore, if the much larger fraction of active galaxies in 3C 295 is typical of other high-redshift clusters, this would indicate a strong evolution of these types.

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