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OPTICAL SPECTRA AND IDENTIFICATIONS

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THE PRESENT STATUS OF 3CR IDENTIFICATIONS

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This paper is a partial and preliminary report on a review of the optical and radio properties of 3CR sources (Kristian, 1977). It will treat the overall status of the identifications and a few of the optical properties of the identified sources, including evidence for a faint magnitude cutoff in the apparent brightness of 3CR quasars. A summary of the status of 3 CR identifications as of early 1976 has been prepared by Smith, Spinrad, and Smith (1976). The present work includes new data on several dozen sources, as well as a systematic reevaluation of previous identifications.

Progress in 3CR identifications has quickened in the last few years. On the radio side, there has been a wealth of new high-resolution, high-accuracy radio maps and positions. The non-negligible number of earlier misidentifications that have been found point up the need for caution in assessing the reality of a given identification without precise radio and optical positions. On the optical side, new instruments enable spectroscopy and photometry to be done on objects that were inaccessibly faint five years ago. Much of the new optical work has been done by Spinrad, Smith, Burbidge, and their collaborators at Lick, and by Katem, Kristian, Sandage, and Westphal at Palomar. The technical means are now available to complete the 3CR survey optically, including spectroscopy and photometry, to a uniform optical limit of V = 22, although the faintest observations are time-consuming, and each one still a small triumph.

At present, one-third of all 3 CR sources are not identified. This includes most low-latitude sources, for which good radio maps and positions are generally not yet available. The identifications of high-latitude ($|b| > 10^{o}$) sources are summarized in the bar graph on the next page. Here "EF" (empty field) refers to sources with good radio positions which are blank to the limit of the best available photographs. "No ID" refers to sources without identification for a variety of reasons (no good positions, complex source, crowded field, etc.). One-fourth of all high-latitude sources are in these two categories and are still unidentified. The symbol "?" refers to good identifications, on the basis of radio-optical position agreement, which are too faint to tell whether their images are galaxies or starlike. Most of the identified QSOs have redshifts and photometry, although there are still a few candidates

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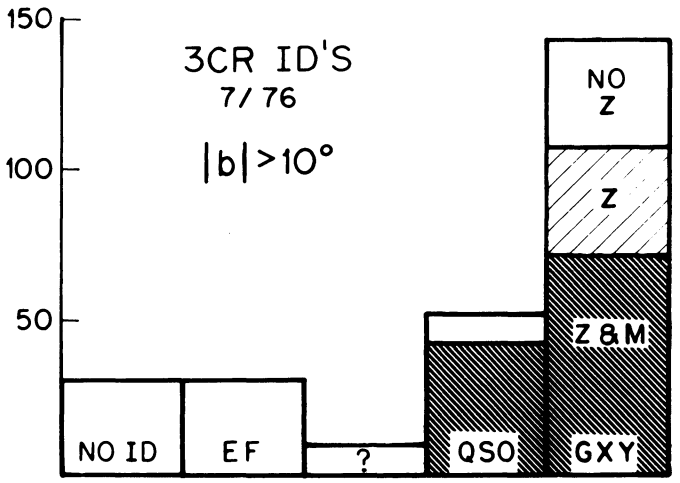
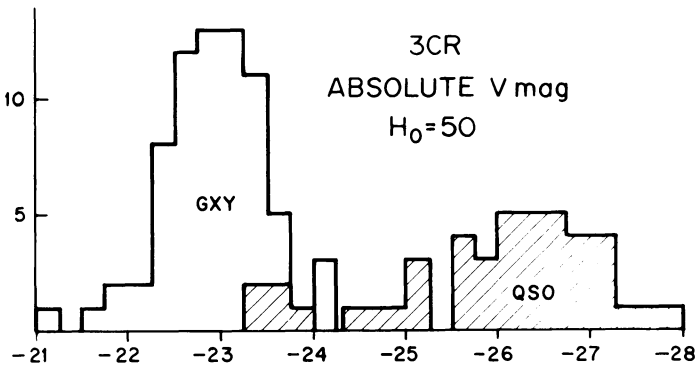


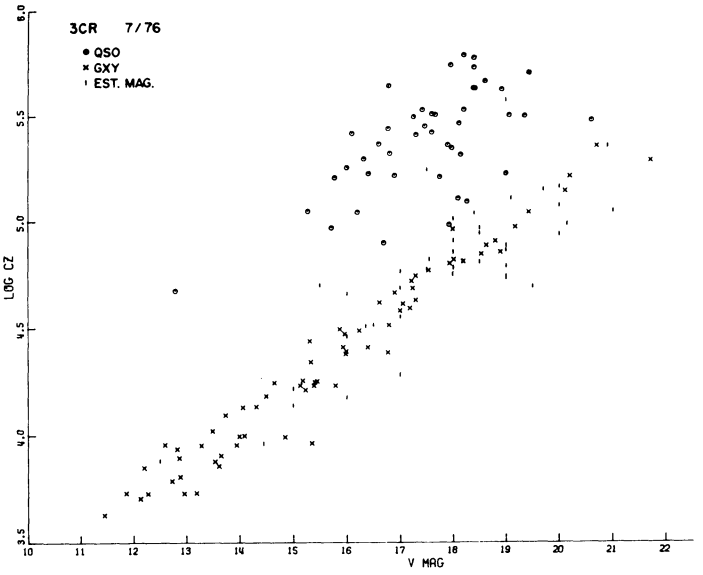
without spectral verification. One-half of the galaxies have redshifts and magnitudes, one-quarter have redshifts only, and one-quarter have not yet been measured optically, although the identifications seem secure from position agreement. Only about the 30 radio-brightest high-latitude sources are optically complete (identifications, redshifts, photometry).

The second figure (see next page) shows the frequency distribution of absolute V magnitudes for all sources with redshifts and photometry. The galaxies have been K-corrected, assuming q_o (formal) = 1, with no evolutionary correction. This has been found (Kristian, Sandage, and Westphal, 1977) to be a good representation of the data for red magnitudes of galaxy clusters to redshift 0.75, including 3 CR sources that are bright cluster members. The galaxy absolute magnitudes are symmetrically distributed between -22 and -24. Three of the four sources fainter than -22 are suspect identifications on other grounds. Of the three galaxies brighter than -24, one is a variable N galaxy and two have redshifts greater than 0.5, where the K-correction is large and uncertain. Ignoring these six objects, the mean absolute magnitude of the galaxies is -22.94 ± 0.42. Including the six increases the dispersion but does not change the mean. This may be compared with the bright cluster galaxy average of -23.30 ± 0.38 (Sandage, 1973). The quasar absolute magnitudes overlap the bright end of the galaxy distribution and extend to -28. The formal average is -25.95 ± 1.14.



The final figure is the Hubble diagram for all extragalactic 3CR sources with measured redshifts (next page). Magnitudes are uncorrected, except for an aperture correction for the galaxies. Vertical lines are objects with magnitudes estimated from plates. The figure shows perhaps the most interesting results so far: namely, a strong decrease in the number of 3CR quasars fainter than apparent magnitude 19.5-20. Such an effect has already been suggested by Bolton (1969) from Sky Survey identifications of Parkes sources, and by Grueff and Vigotti (1975) from deep 48-inch plate material on B2 sources. There has been some reluctance to accept the effect because of the coincidence with the Sky Survey cutoff, but the present sample contains a good deal of deeper plate material.

Almost all quasars lie in the magnitude range 15-19.5, and show a frequency distribution peaked near magnitude 18. In this magnitude range, 40% of all 3CR identifications are quasars. By contrast, in the magnitude range fainter than 19.5, the 3CR Hubble diagram shows 10 galaxies with measured redshifts and measured or estimated magnitudes and only one quasar. Also, there are now 28 additional sources fainter than 19.5 with identifications based on position agreements of 1-3 arc sec. Of these 12 are galaxies, 6 are probable galaxies, 5 cannot be classified from the available plates, and 5 are quasar candidates. Most of the latter two classes are near the bright end of the range. If the cutoff is taken at 20 mag, there are 14 galaxies (6 with spectra), 6 galaxy suspects, 3 unclassified, 1 quasar, and



no additional quasar suspects. These frequencies are in sharp contrast to those at brighter magnitudes, and offer strong support for the reality of the decrease of quasars at faint apparent optical magnitudes.

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DISCUSSION

D. Wills: Which 3CR QSO's do you no longer consider to be correctly identified, and is their number consistent with the estimated surface density of radio-quiet QSO's?

Kristian: There are 2 previously known cases, and perhaps one or two

more that are questionable, pending better data. The numbers I think are consistent with estimated radio-quiet densities. These cases were mentioned as extreme examples - the QSO's generally are in better shape than the galaxies because they have been worked on harder and longer and are mostly above the Sky Survey limit.

G. Burbidge: What about the problem of misidentification. While radio positions may be good to 1" of arc the intrinsic sizes are 10" - 20" or greater, so how certain can one be that the identification is correct? Second, if the galaxy is misidentified, may not the true identification be a fainter galaxy in the same cluster, or a much more distant galaxy with a much larger redshift. Also isn't there a problem with 3C 123 - the radio and optical positions not being in very good agreement.

Kristian: For individual extended sources I have tried to restrict the definition of certain identifications to geometrically clean cases, say a double width 10" - 20" separation with the ID within 1" of the geometrical center, of which there are many examples. The chances of a spurious coincidence to even deep plate limits are very small, and the confirmation has so far been 100% for those objects with spectra. This holds also for galaxies in clusters. For cluster sources with good maps and positions, the identifications have been unambiguously with the brightest cluster galaxy. 3C 295 is a good example, in spite of 2 quite nearby companions to the source. With regard to 3C 123, I have just been told by Pooley (this conference) that the Cambridge map shows a weak central component exactly (< 1") coincident with the galaxy.

H.E. Smith: Three comments about the possibility of misidentifications in the 3CR.

1) The background density of galaxies even to V = 23 is only about 1 per sq minute of arc; thus the possibility of chance coincident is not great.

2) Many objects have spectral pecularities which confirm their identification with active objects.

3) Specifically with respect to 3Cl23, the radio structure is a bit asymmetrical which may account for the apparent discrepancy.