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HIGH *Z* RADIO-LOUD AND RADIO-QUIET QSO ENVIRONMENTS

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We propose a systematic study of the environments of a representative sample of Radio Loud Quasars (RLQ) and Radio Quiet Quasars (RQQ) in two different redshift ranges: z∼3.1 and z∼4. These redshift ranges are optimal for the study of environment evolution in the early universe. Furthermore, the sample of RLQ and RQQ are designed to disentangle the role of galactic interactions in the radio emission phenomenon, and thus, to test the unified model for AGN. Using the GRANTECAN-OSIRIS tunable filters (TF) we expect to build up a distribution function for the emission line galaxies around each quasar. We assume that emission and non-emission line galaxies have similar distributions. This assumption along with photometric redshifts observations will allow us to discriminate between galaxies associated with quasars and field galaxies.

1. INTRODUCTION

Strong evidence for a link between quasar (QSO) activity and the environment of the host galaxy has accumulated over the last decade. Galactic interactions seem to play a significant role in the triggering or fuelling of the nuclear activity. This is supported by the large fraction of host galaxies of QSOs undergoing tidal interactions or merging processes, the high luminosity of these galaxies, and the velocity distribution of galaxies around QSOs (Disney et al. 1995; Carballo et al. 1998; Ellingson et al. 1991).

QSO environments up to $z \sim 0.7$ have been studied both in the visible and near infrared (Hutchings & Neff 1992, 1997; Mcleod & Rieke 1995; Bahcall et al. 1997; McLure & Dunlop 2001; Smith, Boyle, & Maddox 2000). Many of these studies suggest that tidal events may trigger the nuclear activity. Furthermore, they have also shown evidence for differences in the environments of radio-loud and radio-quiet QSOs (RLQs and RQQs hereafter). Yee & Ellingson (1993) and Wold et al. (2000) have claimed significant differences between the environments of RLQs and RQQs at $z < 1$: RLQs would be associated with richer clusters of galaxies than RQQs. However, other groups have not found differences between the RLQs and RQQs, or even normal galaxy environments (McLure & Dunlop 2001; Smith, Boyle & Maddox 2000).

At $z \geq 1$, studies are scarce and usually deal with a few objects. For $0.9 \leq z \leq 1.5$, Hintzen et al. (1991) and Sánchez & González-Serrano (1999) found an excess of galaxies in RLQs. Hall et al. (1998) and Hall & Green (1998) also found an excess of faint galaxies in RLQs with redshifts up to 2. At $0.9 < z < 4.2$, Hutchings et al. (1999) found that RLQs inhabit dense groups, while the RQQs do not.

To explain these results, it has been argued (e.g., Smith, Boyle, & Maddox 2000) that high redshift RLQs ($z \sim 1.5$) are in richer environments than low redshift RLQs ($z \sim 0.5$). This would imply that the environments of RLQs have undergone a significant evolution with time. For $z > 3$ only a few objects have been studied, although it is the most interesting region because beyond this epoch we may be closer to the onset of the activity driven by interactions. Therefore, any environmental evolution has to be studied at $z > 3$.

There are several key questions concerning the cosmic evolution of QSOs. One is the evolution of QSO activity. Do the sites of QSO activity evolve as different environments become favorable? Does the environment evolve at all, or does the environment matter? Another key question is whether the triggering or fuelling of nuclear activity changes with redshift (as the host galaxies age or as the interaction rate changes). Finally, is star formation a cause, effect, or parallel process in QSO events, and do RLQ and RQQ evolve differently? To answer these questions, we propose to study systematically and for the first time, the environments of a representative sample of RLQs and RQQs in two different redshift ranges: $z \sim 3.1$ and $z \sim 4$. The faintness of the galaxy companions makes it necessary to use a large telescope like the GTC. Previous studies have paid no attention to the redshift of the companions, making it impossible to discriminate between background or foreground objects and physical companions. The OSIRIS tunable filters (TF) make it possible to obtain the redshift of the companions using the charge shuffling facility.

2. METHODOLOGY

The stars that populate spheroids (ellipticals and bulges of spiral galaxies) were formed at an early epoch ($2 < z < 7$) and over a short period of time (10^8 yr for a galaxy of the same mass as the Milky Way). This epoch coincides with the first major occurrence of star formation in the Universe (about half of all the stars in the local Universe populate spheroids), which also marks the epoch of galaxy formation. Thus, the young spheroids are identified with the primordial galaxies. During the first starburst, galaxies emit intense UV radiation; in particular, they emit very strongly in the Ly_α (1216 Å) line. The UV spectrum of galaxies at $z > 3$ is observable in the optical and near infrared. Identifying members bers in a galaxy cluster at high z is extremely difficult because normal galaxies are very faint. We propose to look first at emission line companions to the host quasar. Emission line companions appear to be much more abundant in the early Universe. We plan to image our sample of QSOs with a TF ($\Delta\lambda \sim 20$ nm) centered on redshifted Ly_α. Charge shuffling will permit background subtraction and thus the detection of the emission line galaxies. Five exposures are needed to include a circle of $\sim$6 Mpc around the QSO.

From the objects detected in the TF images, we will construct a distribution function for the galaxies in the cluster. Three broad band images at different filters (UBR for $z \sim 3$ and BVI for $z \sim 4$) will allow photometric redshift estimation of the galaxies around the QSO with an error of $\sim$0.1. We expect to detect several galaxies that are also members of the QSO cluster but that do not show emission in Ly_α and were not detected in the TF images. For a galaxy at $z \sim 3$, the object would be undetected in the U filter and easily detectable in B and R. Similar detections would be obtained in BVI for $z \sim 4$ galaxies. With the distribution function obtained from the TF images, we will statistically remove background galaxies from the color-estimated redshifts compatible with the QSO distance.

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