PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, **110**:000–000, 1998 July

MS# 980051 PASP 110(749) Copyeditor: tad
Tuesday Apr 14 12:33 PM

Dissertation Summary

An Optical/Near-Infrared Study of Quasar Environments

PATRICK BRIAN HALL

Thesis work conducted at Steward Observatory, University of Arizona, Tucson, AZ 85721
Current address: Department of Astronomy, University of Toronto, 60 St. George Street, Toronto, Ontario, M5S 3H8, Canada; hall@astro.utoronto.ca
Ph.D. dissertation directed by: Richard F. Green; Ph.D. degree awarded: 1998

Received 1998 January 29; accepted 1998 March 16

I present the data for an optical/near-infrared study of radio-loud quasar (RLQ) environments from $z = 0.6$ to $z = 2.0$ and the analysis of the data from $z = 1.0$ to $z = 2.0$. I thoroughly discuss the sample selection, observing, data reduction, and object cataloging techniques.

I find a significant excess of $K \gtrsim 19$ galaxies in the fields of 31 $z = 1$–2 RLQs, on two spatial scales. One component is at $\theta < 40''$ from the quasars and is significant compared to the galaxy surface density at $\theta > 40''$ in the same fields. The other component appears roughly constant across the fields to $\theta \sim 100''$ from the quasars and is significant compared to the galaxy surface density seen in random-field surveys in the literature. The $\theta < 40''$ component may be produced by as few as ~25% of the fields, but the large-scale component is present in $\gtrsim$50% of them.

The $r - K$ color distributions of the excess galaxy populations are indistinguishable from each other and are significantly redder than the color distribution of the field population, consistent with the excess being predominantly at $z > 1$.

The magnitudes and colors of the excess galaxies are thus consistent with a population of predominantly early-type galaxies at the quasar redshifts, such as would be found in quasar host clusters or groups.

Assuming that the excess galaxies are located at the quasar redshifts, the average excess within 0.5 h_{75}^{-1} Mpc (~65″) of the quasars corresponds to Abell richness class $\sim 0 \pm 1$ compared to the galaxy surface density at more than 0.5 h_{75}^{-1} Mpc from the quasars, and to Abell richness class $\sim 1.5 \pm 1.5$ compared to the galaxy surface density from the literature. This suggests that on a large scale ($\gtrsim 0.75\ h_{75}^{-1}$ Mpc) RLQs at $z = 1$–2 are located within clusters and/or large-scale galaxy structures of Abell richness ~1, and that on a smaller scale ($\lesssim 0.5\ h_{75}^{-1}$ Mpc) within those structures RLQs can be located in unremarkable "field" environments or in groups or clusters up to Abell richness ~0.

For four fields with data in at least rJK_s, I find that the spectral energy distributions (SEDs) of most of the excess galaxies are consistent with them being 2–3 Gyr old early-type galaxies at the quasar redshifts of $z \sim 1.5$, but that there are galaxies whose SEDs cannot be fitted by such simple models. Several objects have SEDs consistent with being 4–5 Gyr old at $z \sim 1.5$ (Fig. 1), and a number of others are consistent with old but dust-reddened galaxies at the quasar redshifts. These potentially different galaxy types suggest that there is considerable dispersion in the properties of early-type cluster galaxies at $z \sim 1.5$. Spectroscopic follow-up will be needed to confirm this suggestion. In particular, age determinations from deep spectra of the candidate 4–5 Gyr old galaxies offer the possibility of constraining the cosmological model by requiring a relatively old universe at large lookback times.

Lastly, there are a number of objects whose SEDs are best explained if they are background galaxies at $z \gtrsim 2.5$. Many of them seem to be dusty or to have composite stellar populations, or both, and some may be already $\gtrsim$2 Gyr old at $z \gtrsim 2.5$.

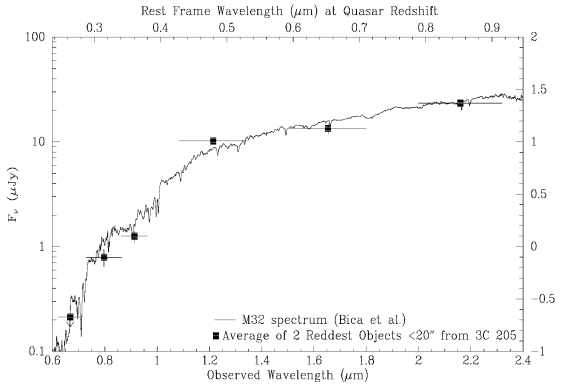

FIG. 1.—(*filled squares*) Average SED for the two reddest objects in $r - K_s$ within $\theta = 20\farcs5$ from Q0835+580 ($z = 1.534$). Horizontal bars indicate the widths of the filters used to construct the SEDs. The solid line is the Bica et al. (PASP, 108, 996 [1996]) spectrum of M32, whose youngest population is believed to be $\gtrsim$4–5 Gyr old.