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## Reddening Independent Quasar Selection from a Wide Field Optical and Near-IR Imaging Survey

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**Abstract.** We present preliminary results from a wide field near-IR imaging survey that uses the Cambridge InfraRed Survey Instrument (CIRSI) on the 2.5m Isaac Newton Telescope (INT). CIRSI is a JH-band mosaic imager that contains 4 Rockwell 1024<sup>2</sup> HgCdTe detectors (the largest IR camera in existence), allowing us to survey  $\approx 4 \text{ deg}^2$  per night to  $H \approx 19$ . Combining CIRSI observations with the deep optical imaging from the INT Wide Field Survey, we demonstrate a reddening independent quasar selection technique based on the  $(g - z) / (z - H)$  color diagram.

### 1. Introduction

To fill the gap between the existing shallow wide-field IR surveys (e.g., 2MASS, DENIS) and deep surveys over small fields of view, we have begun a near-IR imaging survey on the 2.5m INT using the CIRSI mosaic imager (Beckett et al. 1996; Mackay et al. 2000). CIRSI has an instantaneous field of view of  $15.6' \times 15.6'$  on the INT ( $0.45 \text{ arcsec pixel}^{-1}$ ), making it ideally suited to large area survey programs of moderate depth ( $H = 19\text{--}20$ ). In particular, the survey aims to cover  $50 \text{ deg}^2$  in the J and H bands with 5 sigma limits of  $J = 20.6$ ,  $H = 19.1$  ( $\sim 3.5$  magnitudes fainter than 2MASS) during a total of  $\approx 30$  nights in the spring of 2000 and 2001. Even with this modest investment of telescope time we sample a 'local' volume  $\sim 10\%$  that of 2MASS. Thus far we have obtained J and H observations covering  $\approx 5 \text{ deg}^2$  in a Southern Galactic Cap equatorial strip and several  $30' \times 30'$  mosaic images in the ELAIS, Lockman Hole, and XMM fields. The fields were chosen to overlap datasets at other wavelengths, including the deep optical observations of the INT Wide Field Survey (McMahon et al. 2000), and the XMM X-ray data.

The CIRSI near-IR survey has several scientific objectives, including identifying and measuring the space density of cool white dwarfs and T dwarfs, and selecting quasars and damped Lyman- $\alpha$  absorption systems at IR wavelengths (see Warren et al. 1999). The predicted surface density of QSOs with  $z > 2$  and  $H < 18.5$  is  $5\text{--}10 \text{ deg}^{-2}$ , and thus in  $50 \text{ deg}^2$  we expect 250–500 QSOs with  $z > 2$ . The number density of damped Lyman- $\alpha$  (DLA) systems is  $dN/dz \sim 0.1$  (Storrie-Lombardi, McMahon, and Irwin 1996), and thus 25–50 DLA systems

should be detected. These DLA systems are important for comparison to the previous samples detected via optically selected quasars, given the expected bias of the optically derived samples against lines of sight that may contain gas rich dusty galaxies (Pei & Fall 1995).

Here we present the first results from a reddening independent quasar selection technique based on combined optical and near-IR color diagrams. As shown in Figure 1 using model quasar colors, the reddening vector in the  $(g - z) / (z - H)$  color diagram does not drive quasars into the stellar locus (in contrast to purely optical colour-colour plots). The corresponding observed color diagram for a  $30' \times 30'$  mosaic image in the ELAIS region is shown in Figure 2. The CIRSI data were reduced using an automated pipeline (Sabbey et al. 2000), and a SExtractor object catalog was created and merged with the existing Wide Field Survey optical catalog in this field to produce the color diagram. Object identifications from WIYN Hydra follow-up spectroscopy are labelled in the figure. Hydra observations were obtained for a total of four fields during 2 and 3 September 2000, confirming 80 quasars at redshifts  $1 < z < 4$  (including optical-only selected quasars), and reductions and interpretation are still in progress. The preliminary result is that quasar selection using the  $(g - z) / (z - H)$  diagram is a viable technique and is expected to be insensitive to reddening.

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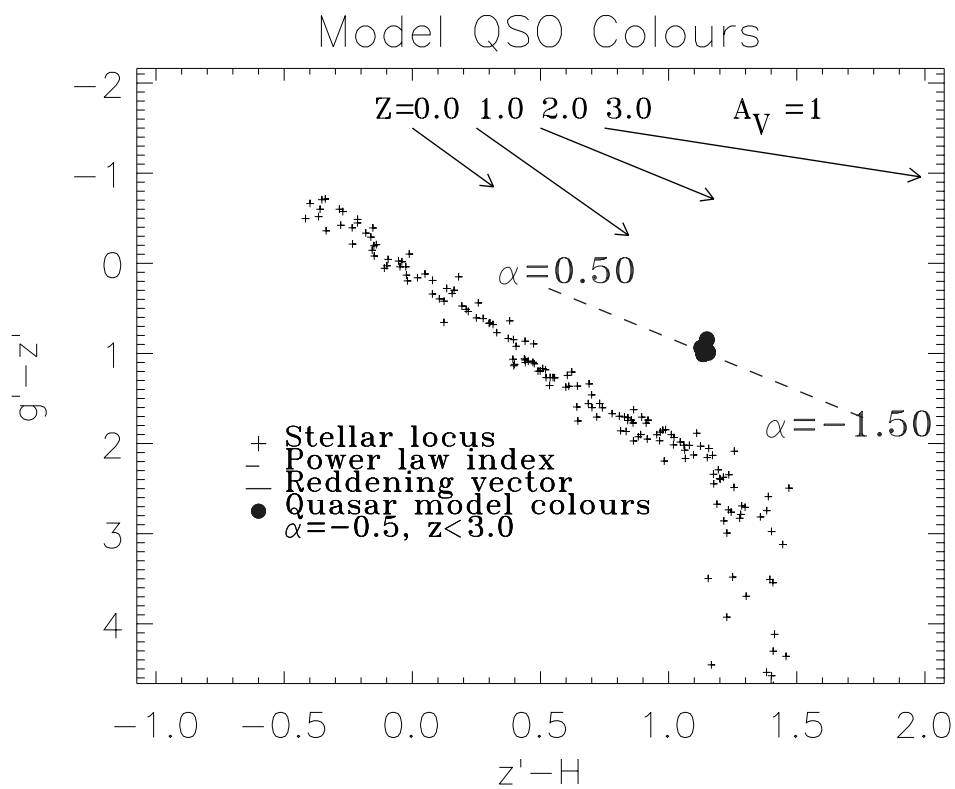


Figure 1. A simulated optical and near-IR colour-colour plot showing the locus of quasars compared with Galactic stars from Gunn & Stryker 1983. The reddening vector does not drive the quasars into the stellar locus unlike purely optical colour-colour plots.

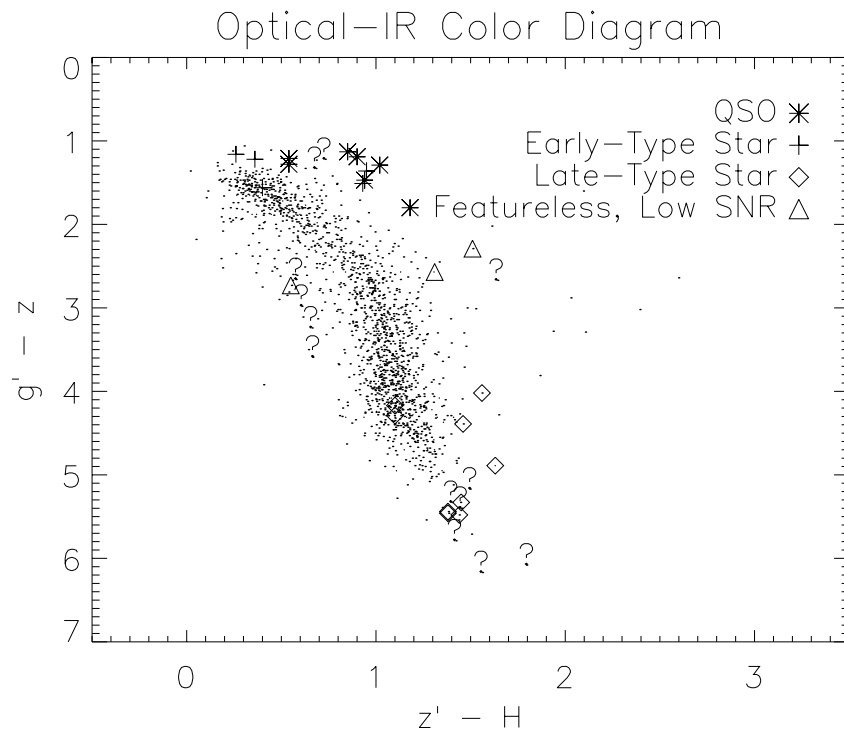


Figure 2. The observed optical and near-IR colour diagram using CIRSI and WFS catalogues for a  $30' \times 30'$  field in the ELAIS region. Object identifications from WIYN Hydra follow-up spectroscopy are labelled.