Searching for Primeval Galaxies at \( z \approx 2.5 \) and 5 Michael

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According to standard Big Bang cosmology, the universe is \( \approx 10-20 \) Gyr old. Somewhere in this time frame, galaxies formed. The detection of a population of galaxies undergoing their first burst of star formation, what are referred to as “primeval galaxies” (PGs), has become one of the most sought after goals of extragalactic astronomy. The importance of finding forming galaxies has far reaching implications for theories of galaxy formation and for constraining conditions in the early universe.

The most conspicuous continuum feature in PGs is expected to be the Lyman break. Compared to foreground sources, PGs should present anomalous colours if imaged with filters straddling the Lyman break. Such a technique has a number of advantages over \( \text{L}_\alpha \) emission-line searches. First, with an appropriate choice of filters, the technique can detect PGs spanning a redshift range \( \Delta z \geq 0.5 \), which is more than an order of magnitude greater than the range over which typical \( \text{L}_\alpha \) narrow-band filter searches are sensitive. Moreover, a continuum search is not as sensitive to the explicit details of star or galaxy formation, or to internal extinction. Furthermore, it is possible to unambiguously eliminate all conceivable sources of confusion.

Steidel and collaborators and De Robertis and McCall (1995, AJ, 109, 1947) independently designed special sets of filters to identify Lyman-break sources around redshifts of 3 and 5, respectively. The former used a set of four broad-band filters to construct colours which isolate the sources from objects in the foreground, whereas the latter employed two narrow-band filters and two broad-band filters to do the same. The advantage of the latter approach is that the narrow-band filters can be tuned to exclude strong night-sky emission. Steidel and his collaborators have been able to carry out spectroscopy to confirm their identifications, proving the existence of a significant population of forming galaxies.

There are some persuasive theoretical and practical reasons to employ the technique of De Robertis and McCall to \( z_{pg} \approx 2.5 \). Not only is this an epoch when the co-moving space density of QSOs was far higher than at present and the epoch when protodisks are thought to form, but both Lyman break filters would be blueward of \( \text{[O II]} \lambda 3727 \), thereby avoiding all potential low-redshift \( \text{[O II]} \lambda 3727 \) and \( \text{[O III]} \lambda 4959, 5007 \) confusion as well as the 4000 Å
break. The statistics of forming galaxies at this redshift would be a valuable complement to those of Steidel and collaborators, in that they would help to isolate the epoch at which star formation rates peaked and the time-scale over which the bulk of star formation occurred.

To carry out this program, filters centered at 3100 Å and 3535 Å with FWHMs of 300 Å would be sensitive to PGs in the redshift range 2.3 – 2.8. Either $B - V$ or $g - r$ can unambiguously separate PGs from other sources of confusion at lower redshifts. Because of the much smaller redshift, searches at $z_{pg} \approx 2.5$ (from 2.3 – 2.8) would be sensitive to a star formation mass almost an order of magnitude less than searches at $z_{pg} \approx 5$.

Mauna Kea would be one of the few sites in the world that could perform such a sensitive search in the UV, providing Megaprime’s optics are transmissive at these wavelengths. Estimates of PG surface densities range from $\sim 10^{3-4}$ deg$^{-2}$, suggesting that a considerable number of objects should be detected in a deep, wide-field survey of the kind being proposed by the CFHT SAC.

There is also considerable merit in carrying out a deep, wide-field survey to search for $z \approx 5$ PGs using the technique already applied by De Robertis & McCall (1995; AJ, 109, 1947). Using intermediate-band filters centred on 5360 Å, and 6100 Å, each with a FWHM of 350 Å, it is possible to detect sub-$L^*$ star-forming galaxies from a redshift $\approx 4.75 – 5.25$, rejecting possible sources of contamination through the acquisition of $R - I$ or $r - i$ data for the same field. The surface density of putative PGs is $\sim 10^{2-3}$ deg$^{-2}$, depending on initial assumptions. This particular redshift régime was selected largely because it involves the faintest part of the night-sky spectrum from Mauna Kea, permitting the maximum sensitivity in the optical window.

Virtually any moderate-to-high Galactic latitude field, avoiding obvious “local structure” would be acceptable for this proposal.

In summary, we propose to use Megaprime to search for PGs in the redshift ranges 2.3 – 2.8 and 4.7 – 5.2 using custom intermediate-band filters, supplemented with standard broad-band filters. The large survey area and depth of coverage will permit the unambiguous detection of hundreds to thousands of putative PGs deg$^{-2}$ at two of the most important epochs in cosmic history.