



## Searching for High Redshift Quasars

An Update From DES and Looking Forward to LSST

Sophie Reed (Cambridge -> LSST DM at Princeton) Richard McMahon (Cambridge), Manda Banerji (Cambridge)

### Quasar Spectrum at z ~ 7

Above z = 6.5 the Lyman- $\alpha$  has an observed wavelength of 9120 Å and starts to move into the Y waveband

Also need near infrared colours to separate quasars from more numerous galactic cool brown dwarfs



## **Brown Dwarf Spectrum**

Above z = 6.5 the Lyman- $\alpha$  has an observed wavelength of 9120 Å and starts to move into the Y waveband

Also need near infrared colours to separate quasars from more numerous galactic cool brown dwarfs



#### Colours at z ~ 7



# The Dark Energy Survey (DES)

First Light September 2012

Very large area when completed: ~5000 deg<sup>2</sup>

Deep imaging: 10  $\sigma$  limits for i and z are AB = 23.4 and AB = 23.2

Sophisticated camera, DECam



#### **DECam**

Mosaic of 62 2k by 4k CCDs (0.27" pixels)

Multi waveband imaging: Visible (400 nm) to Near IR (1050 nm), g, r, i, z and Y bands covered

Much more sensitive to red light than SDSS

Credit: DES Collaboration



# The VISTA Hemisphere Survey (VHS)

Will cover 10,000 deg<sup>2</sup> in the infrared when completed

VHS-DES (J and K) overlaps DES and is deeper

VHS-ATLAS (Y, J and K) is a shallower survey



Credit: ESO

### The Data Used

Dataset made up of a combination of DES data, VHS data and J band driven unWISE forced photometry

Standard DES DM data used and rereduced DES data using a zY detection image



### **Selection Method**

 $\chi^2$  fit to a range of quasar models with different reddening, models by Paul Hewett.

Also fits a series of brown dwarf models. (Skrzypek et al 2014)

Filters are a parameter so can also be used on any survey, overlapping IR data is very useful!



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#### **Selection Method**



#### z > 6 Selection

Now > 20 new z > 6 quasars discovered along with the recovery of lots of known SDSS and PS quasars.





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#### z ~ 7 Selection

Three new quasars with z > 6.7





~25 new quasars at 6.0 < z < 7.0 and recovery of lots of already know ones from a combination of DES, VHS and WISE photometry.

No photometric follow-up required and very high success percentage, > 90%

Method can be used to select quasars without relying on colour cuts - can find more unusual objects.

#### **To The Future!**

#### LSST will be awesome and not just because they pay me



Image Credit: Y. Beletsky, ESO / Todd Mason, Mason Productions, Inc. / LSST Corporation / P. Marenfeld/NOAO/AUR A/NSF

#### LSST

Has the required area, depth and red sensitivity for HZQ searches

Overlaps with IR data - VHS (JHK), Euclid (15,000 sq deg in YJH, split over north and south)

IR depth will be the limiting factor



Credit: @LSST

### **Improved Data Reduction**

Improved outlier rejection dramatically cuts down on junk in the catalogues

Detections in every band better for dropouts



Credit: Yusra AlSayyad

## Expected Numbers (15,000 sq deg)



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#### Proven method from DES easily adaptable to LSST (and any other survey)

#### Known quasars in the footprint for testing new methods

Eventually there will be lots of overlapping IR data (VHS, Euclid, WFIRST) but not too much K band and non uniform.

Should find many new quasars and have the area and depth to push to  $z \sim 8$ .