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SCIENCE AND TECHNOLOGY FACILITIES COUNCIL

Progress report from UKIDSS

Memorandum by the UKIDSS Consortium Survey Scientist, Prof. S J Warren

This report includes, for the first time, individual reports from each of the surveys, as requested by the Board at the time of the reapproval of the surveys. These are contained in the last item.

1. DR3 preparation

DR3 will provide the largest increment in data volume of any UKIDSS release so far, containing all the data taken in semesters 06B and 07A. As a fraction of DR2, and compared to the other surveys, the increase for the LAS will be the largest. In DR2 the LAS covered 280 deg^2 in all filters (with about 230 deg^2 within SDSS DR6). We estimate an additional 550 deg^2 in DR3 for the LAS, all within the SDSS footprint. The increase for the UDS will be modest, as observing conditions were poor when the UDS was observable, and the increase for the DXS will be smallest (as it was previously furthest ahead).

The main contribution of UKIDSS to the release is checking the jpegs of each multiframe. This process has been completed fairly promptly, and has not featured on the critical path. A report on quality control issues is provided in the next section. A few nights of data were considered problematical and were kindly (and very promptly) reprocessed by CASU, and will be included in the release.

The release has been substantially delayed by the late arrival of the November and December 2006 data, which required reformatting at JAC. This has had significant scientific impact as a number of observing programs have been awarded time in November for follow up of DR3. These have had to make recourse to analysis of the flat-file data. We are keen to see a release in the first half of November, perhaps without the GPS, and understand that this may still be possible.

Issues of observing efficiency, and proportion of data eliminated in quality control will be deferred until after completion of DR3, since the second stage of quality control (which requires band merging) has not yet been completed.

2. Quality control issues

We include in this section a rather detailed report on issues arising from the jpeg checking quality control stage. This is based primarily on the checks of the LAS and GPS jpegs, which included the majority of the multiframes in DR3.

The total fraction deprecated is impressively small, which is a tribute to the state of the acquisition and pipeline procedures. Only 1.7% of multiframes are affected, and 1.3% of detectors (because in some cases not all detectors in a multiframe are deprecated). A few bad frames may have been missed

– some of the effects are subtle to the eye. A larger fraction of frames are visibly imperfect, but not so bad that they are worth deprecating. I haven't quantified this, but would put it at about 5%.

The following highlights the main issues, in order of decreasing severity. The first two are important.

- There is clearly still a problem with the moon, especially at an angle near 13°, although at a much reduced level since the baffle was installed. This manifests itself in a variety of ways e.g. arcs, gradients, or generally bad sky. Particularly noteworthy are H sequences on 3/3/07 (UKIRT runs 640-832) and 4/3/07 (UKIRT runs 1173-1249). I strongly recommend that a new observational investigation of the effects of the moon be completed.

- The other main problem is the effect of edge-brightened channels (EBC). This is worst for microstepped frames because, as a rule, each final-image pixel is the average of only two different observations, so that it is not obvious which to choose if the two values are discrepant. In data that are not microstepped, each final-image pixel is typically the average of four different observations. The result of EBCs is typically that either the haloes of objects or the cores of objects are eaten away, with every 4th pixel affected.

  The effect is very difficult to spot from inspection of the jpegs, so some frames have probably been missed. The problem could be eliminated if an algorithm that could reliable idenitfy frames with EBCs could be devised.

- A minor remaining issue is the problem that bright stars affect the sky frames, and so one sees the negative of the star halo in preceding and succeeding frames. It might be possible to predict detector frames containing really bright stars (using a catalogue), and eliminate those detector frames in creating the sky frames.

- There are a few cases where the wrong offsets appear to have been applied for just one of the detectors. Examples have been provided to CASU. The fraction involved is very small.

- There are numerous cases where a bad frame is followed by a good frame. These are easily explained as lost guiding being spotted by the TO, and the sequence repeated. However there is a small number of cases where a good frame is followed by a bad frame. Again examples have been provided to CASU, and again the fraction is very small.

- There are often one or two frames at the beginning or end of a sequence with poor sky subtraction. The fraction involved is minimal, and this is not an area of concern.

3. 07B observations progress

At 22/10/07 UKIDSS had received some 230h observations in 07B. This is a four-month block running from August through November, and, allowing for weather we would expect some 500h of observations. Therefore we are significantly down on expectation (only 70%) at this point. Apart from that, scheduling between the surveys appears to be running smoothly.

Following reapproval of the surveys this Spring, a meeting of Survey Heads was held in Oxford in May. The Board allocation causes a difficulty since it requires the LAS to be complete by the end of 2009, but the main (Spring) block of the LAS is only observed over two seasons (2008, 2009). By contrast the UDS, which has usually been the most problematic survey in terms of getting enough hours in the field, is observed over three seasons (2007, 2008, 2009). For this reason it has been decided to realign the footprint of the LAS, and to include a significant block in the southern Galactic hemisphere, within the BOSS (=SDSS3 footprint). The realignement of the LAS is still under discussion within UKIDSS. Nevertheless inclusion of the best part of 1000 sq degs in the RA range 22h$< RA <$4h appears to considerably ease the difficulty of scheduling introduced by the Board's requirements at the time of renewal. It is intended to sequence this such that UKIDSS releases lag SDSS releases.

We have had discussions with JAC about the impact of the approval of the Transit Survey on the UKIDSS implementation scheme. We have modified the various surveys' implementation schemes to exclude seeing $> 1.1''$. To date the implementation schemes of the UKIDSS elements and the Transit Survey appear to complement each other well.

4. Registration

There has been a steady trickle of new organisations registering for access to the surveys. There are now 78 communities registered, of which 48 are non-UK (AAO are considered UK for this purpose).

5. Publicity

On May 30, at the AAS meeting in Hawaii, JAC and Gemini put out a joint press release on behalf of UKIDSS on the very cool T8.5 brown dwarf ULAS J0034−00, the coolest starlike object known. We are particular grateful to Inger Heyer for a considerable amount of work on the press release. The article on ULAS J0034−00 on the BBC science page was the most popular item on that day. Also at the AAS Andy Adamson gave a review talk on UKIDSS.

6. ESO Workshop, Garching 17-19 Dec 2007

Plans are now well advanced for a workshop at ESO Headquarters in December, with the title 'Science from UKIDSS'. So far 32 people of registered, and the capacity is 80. One of the aims is make the connection between the UKIDSS effort in the UK, and groups across Europe who have not had close contact with the UKIDSS Consortium, and generally to encourage scientific exploitation across Europe.

7. Progress reports from the Surveys

Reports from each of the surveys follow. To complement these we have implemented a web page http://www.ukidss.org/science/science.html reporting published journal papers that use UKIDSS data. The criteria for inclusion are either that the paper includes results that use UKIDSS data directly, or that the paper is specifically about UKIDSS (e.g. a data release paper). We have included the UKIDSS DR2 paper which was not submitted to a journal.

There were 7 UKIDSS publications in 2006, and up to the end of Sept 2007 there have been 17 UKIDSS publications in 2007. In the following we refer to papers by the year and by the number recorded on the web page e.g. Chiu et al. (2007:7). The appearance in press of journal papers lags several months behind science exploitation so the current tally provides an indication of work largely completed around the time of the previous Board meeting. Nevertheless we have chosen not to attempt an exhaustive search of UKIDSS preprints since these will be double counted in our reports to the Board, appearing as a preprint count in one report, and as an increment in papers published in the next report. The citation count to the UKIDSS overview paper, Lawrence et al. (2007:15), which stands at 43 on the date of submitting this report, is a measure of general interest in UKIDSS. We will use this, and the number of published papers, as indicators of achievement.

LAS report (Jameson)

Progress to Oct 2007

Up to Oct 2007 the LAS has covered some 900 $\deg^2$ in the four filters, YJHK, out of a total of 4000 $\deg^2$. It is estimated that DR3 will contain some 830 $\deg^2$ coverage in YJHK, of which all but 50 $\deg^2$ is contained within the SDSS footprint.

Science achieved to date

Very briefly the main science aims of the LAS are to discover new objects from the very faintest and nearest dwarfs to the most distant quasars, as well as to provide complementary near-ir photometry for galaxies included in the SDSS spectroscopic surveys. It is worth remembering that results from the LAS rare-object searches are far from being instantaneous. Once the data have been processed and archived, interesting objects are identified by their colours – see for example Hewett et. al. (2006:1). It is then generally neccessary to carry out some additional photometry, usually in the I and/or Z bands, to stengthen identification and remove contamination from variable and solar system sources before committing precious 8m telelescope time to obtaining spectra, or requesting space telescopes such as Spitzer. This conservative approach is vital to avoid getting a bad name with the 8m TAGs for wasting 8m time.

The major highlight on the cool dwarf front has been the discovery of ULAS J0034−00 by Warren et al (2007, in press, arXiv:0708.0655) – see also the article be Warren et al in the latest UKIRT newsletter. Spectra of this object give a class of T8.5 (the first of its kind), and an effective temperature Te=630 to 690K. There is no evidence for ammonia so it is not a Y dwarf, but it must be close. We also have Spitzer data and the H−4.49μm colour indicates an even cooler Te=600K. The colour is considerably redder than that of its nearest competitor 2MASS J0415-09 (Te=750K). J0034−00 was found in DR1. DR3 will give us more than 3 times the area, so hopefully the discovery of a Y dwarf is imminent.

Numerous other T dwarfs have been discovered by the LAS and published, accepted for publication, or are in preparation. These make an important addition to the family since the original Dwarf Archive based on SDSS and 2MASS only listed some 50 T dwarfs. Briefly the new LAS discoveries are as follows. Kendall et al (2007:8) published 2 T darfs from the LAS early data release. Lodieu et al (2007:13) published eight T dwarfs ranging from T4.5 to T7.5 found in DR1. Pinfield et al (in preparation) have another 10 T dwarfs ranging from T3.5 to T7.5. This means that in total 19 new Ts have been discovered by the Cool Dwarfs Stars Working Group – remarkably with 100% success rate from 8m spectroscopy.

Chiu et al (2007, submitted) have found four T dwarfs from T2.5 to T7.5 from 136 deg^2 in SDSS Stripe 82. These, together with other LAS T dwarfs from the same area give 9 T dwarfs in this well-studied area. Extrapolating this number to the full survey area suggests the LAS will find 265 T dwarfs by similar techniques. Extrapolating to the full depth i.e. to $Y = 20.3$, means that the LAS would yield 461 T dwarfs in total (reaching deeper requires more follow-up photometry and therefore takes longer). This is an impressive improvement on the present known number of T dwarfs but falls short of the theoretical predictions by Hambly and Deacon (2006:2). Using proper motions, see below, could also further increase the number of T dwarfs discovered.

Burningham et al are writing a paper on the LAS late L to mid T dwarf luminosity function from purely photometric selections. Two groups are also searching for metal poor L subdwarfs but have, as yet, not made any confirming spectroscopic observations. Interesting results have also been obtained on white dwarfs. Vidrih et al (2007, in press, arXiv:0709.1131) have used the SDSS stripe 82 plus LAS infrared data to find a sample of 1049 cool white dwarfs, of which at least 8 and possibly as many as 21 are new ultra cool (Te<4000K) DA white dwarfs, and one is a new ultra cool DB white dwarf. Ten new halo white dwarfs are also identified from their kinematics. Burleigh and Steele (in preparation) have used the LAS DR1 to search 160 known white dwarfs for infrared excesses. One WD is found to have a K band excess that has been verified spectroscopically. This excess can be fitted with a cool blackbody and is thought to be either a debris disc or possibly a carbon dust shell.

Moving to extraGalactic science, two LAS papers have been published so far. Venemans et al. (2007:4) describe the discovery of the first $z \sim 6$ quasar in the LAS, from the first $100\,\mathrm{deg}^2$ analysed . The source redshift is reported as $z = 5.86$, but subsequent near-ir spectroscopy with GNIRS shows the object to be a BAL quasar with a lower redshift of $z = 5.75$. A further $130\,\mathrm{deg}^2$ has now been studied with no new detections, although a handful of good candidates remain. The success rate so far is consistent with expectation, and DR3 should contain a handful of high$-z$ $z > 6$ quasars.

Chiu et al. (2007:7) report on a combined SDSS+UKIDSS study of the colours of quasars, over a wide redshift range. In the latest UKIRT Newsletter, Issue 21, Maddox et al. describe the results from a spectroscopic study, with AAOmega, of a sample of quasars selected by the K-band excess (KX) method. The sample, while small, contains a number of quasars at $z > 3$ missed by SDSS, and a surprising proportion of BAL quasars. A greatly enlarged sample will be obtained during November 2007, in a 14-night run with AAOmega.

The first preprint on the combined SDSS+UKIDSS colours of galaxies in the main SDSS spectroscopic sample has appeared. Eminian et al. (2007, arXiv:0709.1147) find that galaxies with a high specific star formation rate have blue optical colours, but red near-ir colours. This result agrees qualitatively with the predictions of models in which Thermally Pulsing Asymptotic Giant Branch stars dominate the H and K-band light of a galaxy following a burst of star formation (as originally suggested by Maraston), and is potentially important for the derivation of ages from the colours of galaxies at high redshift.

The UKIDSS LAS was originally conceived as a 7 year project. The LAS has now been speeded up with the aim of completing the survey before the end of 2009. It should be noted that this makes impossible one of the major aspects of the survey, namely to obtain proper motions from a second pass J band survey. This second pass should be done at least 3 years after the first pass, i.e. after 2009. For cool dwarfs these proper motions will be extremely valuable. They will indicate, particularly for the intrisically faintest sources which might only be detected in the J band, that an object is near, cool and interesting. Proper motions will be vital in achieving the full volume potential of the LAS for cool dwarfs.

7.2 GPS report (Lucas)

GPS progress

The GPS component of the UKIDSS 2nd Data Release was released on 12th April 2007, six weeks after the rest of UKIDSS. This was due to the very large number of sources in the GPS, which is far greater than the other UKIDSS surveys combined. It takes a long time to ingest the photometry into the archive and merge detections in the three passbands.

At the DR2 release the GPS was 12.5% complete and covered 50% of the Spitzer GLIMPSE-north and GLIMPSE II survey regions at Galactic longitudes $l = -2$ to 65 in all 3 near infrared passbands. This was the first GPS data release with sufficient three band coverage to begin serious scientific exploitation.

Observations in the November 2006 to May 2007 WFCAM observing block proceeded well: for the first time almost all of the GPS observing allocation of 160 hours was actually used. This was in part due to a relaxation of the seeing requirement on 10th February, from 0.8 arcsec to 1.0 arcsec (at K band), for the relatively uncrowded outer galaxy half of the survey that is observed during winter time. Since the seeing is often poor in winter time we plan to continue this policy.

The high completeness rate was also aided by the extension of the WFCAM block into May, which allowed us to observe the summer plane (i.e. the central parts of the Galaxy) toward the end of the night. The southern strip of the GPS in the midplane at Galactic coordinates (l,b) = (-2 to 15, -1.3 to +1.3) was completed by the end of the observing block, along with much of the more northerly region at l=15 to 40. In view of the fact that the VISTA-VVV survey (co-led by Lucas) is due to begin in 2008 or 2009, we have decided not to complete the small sections of the southern strip above and below the mid-plane at b=-2 to -1.3 and b=+1.3 to 2, for which there is no Spitzer data.

In the current observing block (August to November 2007), we attempted to complete the Spitzer-GLIMPSE north region at l=15 to 65, b=-1.3 to +1.3, along with the rest of the summer mid-plane up to l=107 and sections of the winter plane. Fair progress was made on the summer plane but we were unable to complete it due to the problem with the WFCAM cold head, which caused 12 UKIRT nights to be lost in early September. However, we are very confident that the top priority Spitzer GLIMPSE and GLIMPSE-II regions will be completed in summer 2008.

Finally, we note that some K+H2 imaging of the off-plane Taurus-Auriga-Perseus molecular cloud complex is continuing in DDT time. This part of the GPS was cut in the February 2007 review of UKIDSS, leaving the survey coverage in a very patchy state. The original multi-epoch survey was probably over-ambitious but we are attempting to complete single epoch coverage of the denser cloud cores in PATT time and DDT time and make the results publically available. This investment of a few nights of UKIRT time will create a useful public resource and greatly add value to the data already taken under the auspices of UKIDSS.

Exploitation

Members of the GPS implementation group are pursuing scientifically diverse research programmes with the data. The more active research efforts that we are aware of are listed below.

1) The GPS group paper, "The UKIDSS Galactic Plane Survey", (Lucas et al. with some 20 authors), is very close to completion. It is expected to be submitted in November 2007 and im-

mediately placed on astro-ph for the benefit of the wider community. A draft can be viewed at `ftp://star-ftp.herts.ac.uk/pub/Lucas/gps_v4.pdf`. This paper contains (i) a detailed users' guide to GPS data in the archive; (ii) a description and analysis of the data as a function of Galactic coordinates; (iii) six science results from Science Verifiaction data and DR2 data. These include (1) details of how best to combine WFCAM and Spitzer-GLIMPSE data to identify and classify protostars; (2) analysis of the H2 data in Rho Ophiuchi; (3) a UKIDSS/Chandra cross-match near the Galactic centre; (4) a description of the detectability of external galaxies at $d < 100$ Mpc in the Zone of Avoidance; (5) a first demonstration of the benefits of the combining UKIDSS and IPHAS optical data for spectrophotometric typing and luminosity classification of field stars.

2) Hertfordshire. (Lucas, Samuel, Gallaway, Burningham, Drew). In order to investigate the environmental dependence of star formation we are searching for new young clusters and star formation regions to analyse. These will be added to lists of clusters in recent 2MASS and GLIMPSE publications.

Lucas and Burningham have identified aproximately 20 new star formation regions by visual inspection of the DR2 jpeg images during quality control. In addition, Samuel has constructed a Bayesian algorithm to automatically search the source catalogue for new clusters. The algorithm has been tested on subsets of the data and is now ready to go on the full DR2 catalogue. We have downloaded a simplified version of the catalogue from Edinburgh with the assistance of the archive team.

Both these efforts are expected to lead to publications being submitted by the time of the May 2008 Board meeting.

We have also recently discovered a new Galactic globular cluster hidden in the mid-plane by high extinction, which will merit a publication in collaboration with GPS group members at Southampton, Sheffield and Edinburgh. This cluster has an XMM X-ray source, whose nature we are attempting to establish.

Gallaway will begin his PhD in January 2008, working on GPS data on high mass star formation regions identified in the MMB methanol maser survey.

Lucas will also attempt an unbiased GLIMPSE/GPS cross match to identify new clusters by locating concentrations of sources with K-4.5μm colour excesses.

Finally, Prof Drew has recently joined the Herts group. Her student (Sale) will be publishing papers on IPHAS/GPS spectrophotometric typing and extinction mapping of the plane.

2) Kent. (Smith, Mitchison). These researchers are close to completing a paper on the Science Verification JHK data in the Rho Ophiuchi cloud, as part of Mitchison's PhD thesis. A second paper on the H2 data will follow, building on the summary of results presented in the GPS group paper.

3) Leeds. (Hoare, Stead). This group is using GPS data to analyse clusters associated with massive

YSOs from the Leeds RMS survey. Stead is now in the 2nd year of his PhD and is expected to produce a paper in 2008 on a method for dereddening young cluster members and calculating distances and ages.

More generally, Hoare and Lucas will be attempting to cross match GPS and CORNISH radio data when these surveys are nearer to completion.

4) Florida/Oxford. (Bandyopadhyay, Gosling).

These researchers have for some time been attempting to cross match the 1000 Chandra X-ray sources near the Galactic Centre with UKIDSS GPS stars. Preliminary results are presented in the group paper. A fuller and more detailed paper will be prepared separately after the corrected data become available in DR3. (Much of the Galactic centre data was corrupted by the bug in the cross removal process that was mentioned at previous Board meetings). The poor data have been reprocessed by CASU and WFAU promise to add it to DR3.

5) JAC (Davis, a student, and Adamson)

This group is involved in the continuing effort to observe the denser parts of the Taurus-Auriga-Perseus region in the H2 filter. The existing GPS data from DR2 are being mosaiced and placed into an interactive database at JAC, along with some recent DDT data. A first paper advertising the database and analysing observations of the Perseus cloud core is in preparation. The distribution of H2 and HH objects is being compared to establish the efficiency of both in outflow surveys. Spitzer IRAC catalogues from the Cores to Disks Legacy survey are being used to identify embedded sources in order to statistically analyse the driving sources of the H2 outflows.

6) Sheffield (de Grijs).

de Grijs is working on the M17 Science Verification data with the aim of comparing the IMF in different parts of this massive star formation region and measuring the amount of dynamical mass segregation.

7) IAC. Lucas and other members of the GPS group have recently been asked to join a Campaign proposal led by the GranteCan/EMIR instrument team (PI Garzon-Lopez) for large scale near infrared multi-object spectroscopic follow up of Galactic sources.

7.3 GCS report (Hambly)

(Note: this report is taken from the GCS update article in the most recent UKIRT Newsletter.)

The UKIDSS Galactic Clusters Survey (GCS) aims to measure the form of the substellar initial mass function (IMF) in a variety of star formation environments. The IMF at higher masses $m \gg 0.1\ M_\odot$ is relatively well characterised and there is considerable evidence of a universal mass spectrum regardless of Galactic environment (age, metallicity etc.) which in turn points to a universal star formation process. The same cannot be said, however, for the substellar IMF. Different surveys employing different techniques (limited multicolour selection; proper motion selection; optical versus infrared studies) produce quite different substellar IMFs and the following questions stubbornly remain to be answered:

- what is the functional form of the substellar IMF in the mass range $0.1 > m/M_\odot > 0.01$?
- to what degree does the substellar IMF vary with Galactic environment?
- is there a turn-over, or characteristic mass in the substellar IMF?

The UKIDSS GCS aims to answer these questions, and more, via a uniform survey of ten Galactic open clusters and star formation regions. By detailed study of a homogeneous data set the intention is that problems such as completeness, unresolved binarity, and dynamical evolution effects (especially in the presence of limited spatial coverage), all of which have vexed studies to date, will be addressed and the questions posed above can be answered fully and accurately. This is important, for example, because the amount of mass locked up in substellar objects as a fraction of the total mass in stellar systems is presently unknown, and the relationship between the lowest mass brown dwarfs resulting from the star formation process and the highest mass planets remains to be determined.

Observations and survey release for the GCS are progressing well as part of the overall UKIDSS programme. The latest data release DR2 (Warren et al. 2007:5) contains around $500\,\mathrm{deg}^2$ of GCS data covered in at least one waveband; full details of the GCS coverage are available online at `http://surveys.roe.ac.uk/wsa/dr2_gcs.html`. At the time of writing (Autumn 2007, during preparations for DR3), GCS observations are 100% complete barring a small amount ($< 10\%$) of quality control losses in the five infrared passbands ZYJHK for the targets IC4665, Praesepe and Perseus-OB2. Observations are 100% complete in K for the Hyades and Coma-Ber clusters, while ZYJHK completion fractions for the remaining 5 targets are: Pleiades $\sim 60\%$; Alpha-Per $\sim 50\%$; Upper Sco $\sim 30\%$; Orion $\sim 16\%$; and Taurus-Auriga $\sim 11\%$.

Science results so far from the GCS are published in four refereed journal papers by Lodieu et al. Highlights include the identification of new brown dwarf members in Upper Sco to masses $m < 0.01\ M_\odot$ (Lodieu et al., 2007:1); detailed infrared spectroscopic follow-up at low and intermediate dispersion (Lodieu et al., 2006:5, and 2007, submitted) illustrating the power of the GCS multi-colour/multi-epoch candidate member selection process; and a detailed study of the Pleiades substellar sequence including the binary fraction and IMF (Lodieu et al., 2007:17). In the latter, we show that the IMF into the substellar regime is well modelled by a log-normal distribution having a characteristic mass of m$\sim$ 0.2 $M_\odot$.

In addition to work spear-headed by Lodieu (Instituto de Astrofisica de Canarias, Spain), groups working with UKIDSS GCS data include those led by Hogan, Casewell and Jameson (Leicester University, UK) working with Coma Ber, Hyades and Pleiades data (papers submitted and/or in preparation), Barrado-y-Navascues (Laboratorio de Astrofisica Espacial y Fisica Fundamental, Spain) and Martin (IAC) working with Taurus-Auriga data, and Cararro (Padova University, Italy) working on IC-4665.

7.4 DXS report (Edge)

The Deep eXtragalactic Survey, DXS, has been making gradual progress over the past year since the renewal application. The DXS has had proportionately less time over the last 12 months to compensate for the higher completion rate in the DXS compared to the other surveys in the first 18 months of operations. This will not significantly affect the exploitation of the forthcoming DR3 release as there are enough fields at full depth to establish the potential of the full DXS.

The first refereed paper from the DXS working group has been published (Swinbank et al. 2007:14) which presents Gemini-N spectroscopic follow-up of the distant clusters of galaxies found in the first DXS field to be released, Elais-N1. The somewhat surprising result from this analysis was that there is a supercluster at z=0.9 in this field and all five targeted clusters lie within it. This result was also presented in the latest UKIRT Newsletter. This work is continuing with Gemini-N observations of clusters in the most complete DXS field to date, SA22, led by John Stott (LJMU, ex-Durham). This past month has also seen the completion of the first PhD thesis based on UKIDSS DXS data, by John Stott.

The majority of the DXS work to date has been related to clusters as the larger, statistical aspects of the DXS (number counts, clustering, multi-wavelength studies) require more area coverage or new surveys to start (e.g. SCUBA-2, Herschel, FMOS). At the start of the UKIDSS surveys both SCUBA-2 and FMOS were anticipated to be operational by this point but this is not the case so we have more time to prepare for them instead.

The issue of ensuring the best suite of supporting observations for the DXS has continued to occupy the DXS Working Group and the successful CTIO 4m MOSAIC imaging of SA22 in September 2006 has allowed a number of new projects to be attempted. For instance, both AAT AAOmega and VLT VIMOS time have been requested for spectroscopy of $1 < z < 1.3$ luminous, red galaxies (LRGs) in SA22 to provide limits on the evolution of the most massive galaxies at this redshift which would provide stringent limits of galaxy formation models. The AAOmega proposal was unsuccessful but in a semester when the UK time was reaching an impractically small fraction, and the VLT proposal is pending. We will continue to pursue all avenues for spectroscopy for these rare, luminous objects which are poorly sampled in all current 8m spectroscopic surveys (e.g. DEEP2, VVDS and the UDS VIMOS follow-up) due to the combination of colour selection and/or sparse sampling.

The imminent start of the PanSTARRS survey which will produce a deep, five band optical datasets for all four DXS fields, and will provide a public dataset at the point at which the final DXS also becomes world public. This has a positive long-term result but in the short term makes it difficult obtain new optical imaging in these fields. The UDS has benefited greatly from the complementary optical coverage offered by the existing Subaru Deep Field imaging whereas the equivalent analysis with the DXS may require more time to attempt.

The survey plans for SCUBA-2 and Herschel have a significant overlap with the DXS and a large XMM-Newton proposal has just been submitted for $8\,\mathrm{deg}^2$ of deep imaging in DXS and other multi-wavelength fields in the south (PI Alexander, Durham). If successful, this project would dramatically increase the X-ray coverage in the DXS fields.

Finally, the ArcMinute Imager, AMI, Sunyaev-Zel'dovich experiment in Cambridge is about to start blind survey observations with the two northern DXS fields as primary targets. The DXS data will be central to the rapid identification and redshift estimation of the AMI-selected clusters.

Work on a wide variety of projects has been using DXS data as a source of primary or secondary data. For instance, Geach et al. (2007:2) use DXS data for two z=3.1 Lyman α selected galaxies in SA22 in a paper on Spitzer detections, while Polletta et al. (2007:12) used DXS data in a study of sources in the XMM-Newton Medium Deep Survey. Also DXS data are being used for work on SWIRE fields in Sussex and Bristol, for SHADES identifications in Edinburgh and radio galaxies in Oxford and Hertfordshire. Several new PhD students have recently started projects on DXS-related projects so the active user-base of the DXS continues to expand. The DXS data will also be used within the HiZELs project (coPIs Smail and Best) which was awarded WFCAM campaign time for a narrow band survey at three carefully chosen wavelengths to determine the evolution in the star-formation rate in the Universe.

In the forthcoming year, we look to the Feb-June 2008 block to concentrate on the Lockman Hole and Elais-N1 fields to bring them up to the completeness of the SA22 field. The WFCAM scheduling and weather in the Spring in 2006 and 2007 was not ideal for these fields. By the time of the next report the number of completed DXS fields should be 14–16, nearly a third of the final area.

In conclusion, the DXS is producing data that are being used widely within the UK community. The scientific output from these data is not as high as the UDS due largely to the poorer optical and multi-wavelength coverage at present. This situation will change radically by the end of 2010 with the release of a wide range of new datasets.

7.5 UDS report (Almaini)

Survey progress and expectations for UKIDSS DR3

The UDS DR1 is already the deepest infrared survey ever conducted over such a large area, and steadily increasing in depth. The only comparable infrared imaging survey is the Ultra-VISTA project, which has yet to begin and is unlikely to supersede the UDS until 2011-2012.

The UKIDSS DR3 (scheduled for November 2007) will be the second major release for the UDS, combining two seasons of data. The quality control, data preparation and stacking is ongoing, but the expected depths are $K = 21.7, H = 22.0, J = 22.9$ (Vega, 5σ, point-source) over the full 0.8 deg^2 field. The major advance over DR1 will be the addition of H-band data, which will be particularly powerful for constraining photo-zs of galaxies at $z > 3$. In addition, the Nottingham team have refined the quality-control and data stacking techniques for the UDS, leading to stacked images with fewer cosmetic defects and a gain in depth of up to ~ 0.1 magnitudes.

The overall gain in depth from DR1 to DR3 will be far less than originally anticipated, however. This was due to exceptionally poor seeing in Nov/Dec 2006, which led to very little UDS data being taken beyond 25 hours in the $H-$band (which has the most relaxed constraints). These poor conditions affected the UDS disproportionately because of the scheduling of WFCAM in 2006, which missed the optimal months for observing this 2-hour field (September and October).

In contrast, progress in 2007 has been excellent so far. At the time of writing (October 18) the field has been observed for over 90 hours this semester, which is already close to doubling the total exposure in the UDS. This should provide a substantial advance in depth for DR5 in late 2008.

New complementary data and the ESO Large Programme

Over the last year, very large allocations of telescope time have been awarded to the UKIDSS UDS project on other facilities. Key among these are a new ESO Large Programme and a Spitzer Legacy proposal. These awards demonstrate the world-leading international reputation the survey has already developed and the growing legacy value of this unique deep field.

- An ESO Large Programme was awarded to conduct a spectroscopic survey of K-selected galaxies from the UDS (PI: Almaini). This will be an order of magnitude larger than any comparable K-selected survey to date, involving 235 hours on the VLT using a combination of the VIMOS and FORS2 multi-object spectrographs. This was the largest allocation of ESO time in 2007. There are many scientific aims, but a key goal is to conduct the first detailed study of large-scale structure and the evolution of bias over a large period in cosmic history ($1 < z < 5$). A further aim is to determine how galaxy *environment* affects the evolution of galaxies and quasars at high-redshift, and directly measure the build-up of galaxy populations as a function of cosmic time.

- A Spitzer Legacy proposal has been awarded (291 hours) to survey the full UDS field (PI: Dunlop), using the four IRAC bands in addition to MIPS at 24 and 70 microns. The IRAC depths of ($AB \simeq 24$) are chosen to match the eventual depths of the UDS in J, H, K. These Spitzer observations are designed to obtain reliable stellar masses for high-z galaxies detected in the UDS, to help distinguish star-forming from passive stellar populations, and to provide the vital long-wavelength data required to effectively identify large numbers of very high-redshift ($z > 6$) galaxies.

- Time has been awarded on CFHT Megacam (PI: Almaini) and the WHT (PI: Balcells) to obtain very deep U-band imaging for the UDS field. These data will allow unobscured star-forming galaxies to be selected at $z \sim 3$ using the classic Lyman-break technique and will provide much-improved photometric redshifts and SEDs for K-selected galaxies.

Scientific output and publications

A number of high-profile results have already emerged from the UDS. These include the discovery of very luminous Lyman-break candidates at $z > 5$ (McLure et al., 2006:3), a study of the clustering of Distant Red Galaxies (Foucaud et al., 2007:6) and remarkable evidence that the galaxy colour bimodality (the red sequence) disappears beyond $z = 1.5$ (Cirasuolo et al., 2007:16).

Excluding the UKIDSS survey definition papers, there are already 8 publications based directly on UKIDSS UDS data. These include the 3 reported above, as well as van Breukelen et al (2006:6), Simpson et al. (2006:7), Lane et al. (2006:10), Martinez-Sansigre et al. (2006:11), and a preprint by Magliocchetti et al. (arXiv:0710.3136) on the clustering of Spitzer 24μm sources. We are aware of several groups actively working on UDS data across the ESO and Japanese communities, so we expect this number to rise substantially.

Figure 1 shows new work from the Nottingham group (Hartley et al., in preparation) on the clustering of high-z galaxies selected using the BzK technique from the UDS DR1. It was found that galaxies with colours consistent with passive stellar populations remain the most strongly clustered even at $z > 1.4$ (a look-back time of 9 billion years). This points directly to a very early epoch of formation for galaxies in the most massive dark-matter halos.

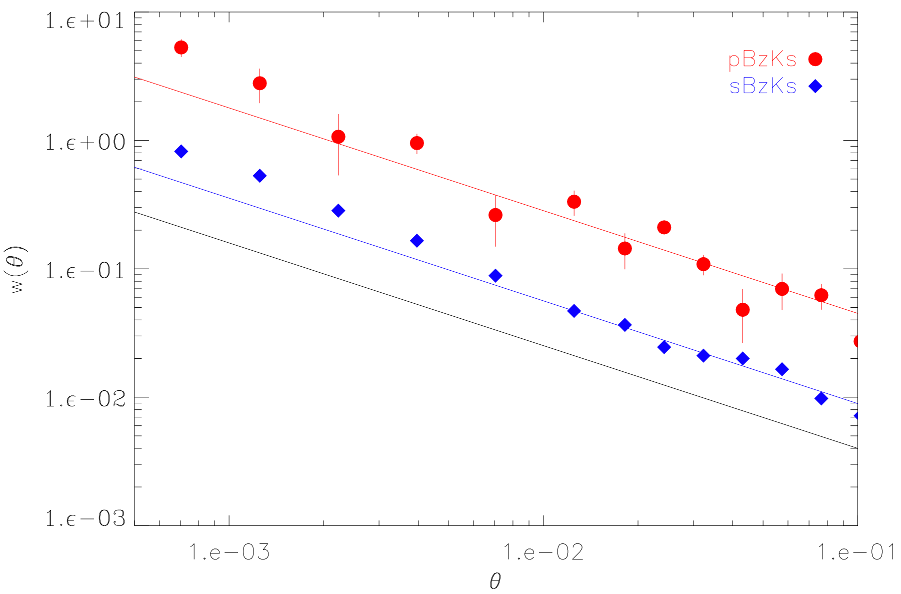

Figure 1: *Angular correlation functions for $z > 1.4$ galaxies selected from the UKIDSS UDS using the BzK colour selection technique, separated into passive (pBzK) and star-forming (sBzK) subsets (from Hartley et al., in preparation). The best-fitting models assume the canonical $\theta^{-0.8}$ power law. The lower solid line shows the correlation function for the full sample of K-selected field galaxies.*