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500 K and Below - Finding Ultracool Dwarfs with the UKIRT/WFCAM and VISTA surveys

P.W. Lucas[1] + UKIDSS Consortium + VISTA Consortium

Abstract. I describe the very large area infrared UKIRT surveys which will begin in 2003 and their impact on the field of brown dwarf searches. These surveys will reach K≈19 and survey on the order of 20% of the sky. Present plans are for ZJHK imaging, with repeats in J or K to detect proper motions. It is expected that brown dwarfs in the 400-500 K range will be detected, possibly reaching the threshold at which liquid water droplet clouds will form in the upper atmosphere. Some planetary mass 'sub-brown dwarfs' may also be detected if any exist within 10 parsecs. These surveys form natural successors to 2MASS, DENIS and SLOAN. The 4-m VISTA telescope will conduct similar surveys in the southern hemisphere beginning around 2005-6.

1. The UKIRT Wide Field Camera

Design and Construction at the UK Astronomy Technology Centre, Edinburgh.

Project Scientist: Mark Casali. See Casali (2001) for further details.

Site - Mauna Kea, Hawaii. Northern Hemisphere, Latitude +19°.

Telescope - 3.8 m United Kingdom Infrared Telescope (UKIRT).

Typical seeing 0.5-0.6 arcsec with tip/tilt secondary.

WFCAM Optical Design

New f/9 secondary mirror for UKIRT.

Forward Cassegrain quasi-Schmidt camera design includes reimaged pupil and cold stop for maximum K band sensitivity.

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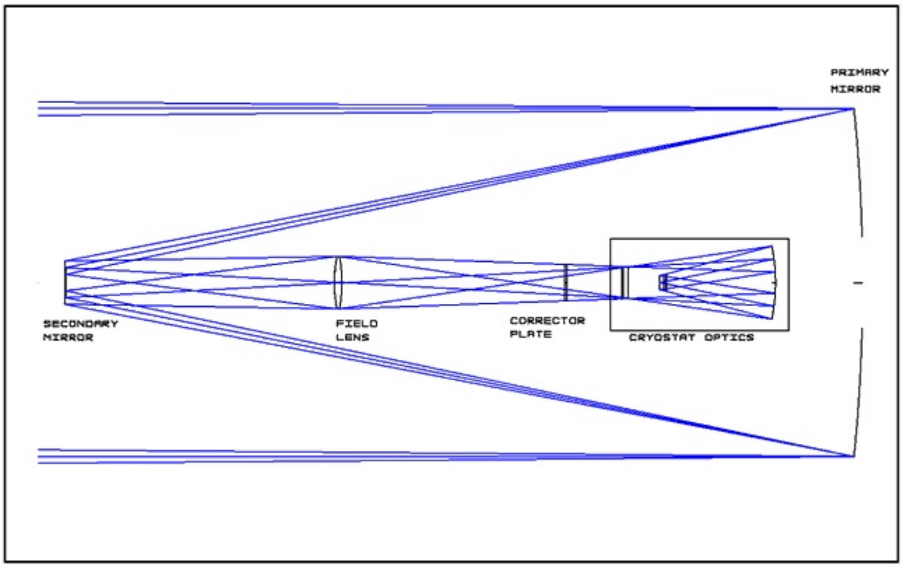

Vacuum optical image quality < 0.26 arcsec rms.

0.93° diameter field (not filled).

Detector Specification

Four 2048×2048 Rockwell PACE arrays spaced by 90% of a array size.

0.8-2.5 μm sensitivity.

0.4 arcsec pixels giving single exposure coverage of 0.2 degrees^2.

4-shot tile gives 0.76 degree^2 contiguous field with small overlaps.

Microstepping ensures proper sampling of the PSF.

Data Processing

Real time reduction of images. Photometry offline in the UK.

Web Accessible Atlas and Photometric Archive to be based in the UK.

2. UKIDSS - UK Infrared Deep Sky Survey

Who? A large Consortium of UK astronomers with diverse research interests. Also Japanese involvement - SUBARU will follow up UKIDSS data.

What? UKIDSS exists to design large surveys with WFCAM, which will take 5-10 years in the initial phase, from 2003.

Data Rights.

No proprietary time for UKIDSS

All data immediately public to UK and associated Japanese astronomers.

Data becomes world public after 18 months.

3. UKIDSS Science Plan

Motivation - Address the most important astrophysical goals presently identifiable and create a Legacy Database and Atlas covering a significant fraction of the sky.

Plan - A wedding cake strategy of large, relatively shallow surveys and progressively smaller deeper surveys.

Large Area Survey (LAS) - SLOAN region 4000 deg^2 high latitude shallow survey. K=18.4.

Galactic Plane Survey (GPS) - 1800 deg^2 covering the northern half of the plane. K=19.0

Galactic Clusters Survey (GCS) - shallow survey of 11 nearby open clusters and star formation regions (K=18.4), specifically for brown dwarfs and the IMF.

Deep Extragalactic Survey (DXS - 70 deg^2, K=21, studying clustering and structure at high redshift. Broken into several regions in XMM Deep Survey region, Lockman Hole and Chandra South survey areas already observed in other wavebands.

Ultra-Deep Survey (UDS - 0.76 deg^2, K=23. Cosmic evolution of ellipticals at high redshift.

Approved High Priority Surveys: LAS, GPS and GCS. DXS and UCS presently at low priority requiring revised plans. Cosmologists lose out!

4. UKIDSS and Brown Dwarfs

LAS: Equal time YHK + 2× J observation of 4000 deg^2 high latitude SLOAN region.

J band observations broken into 2 passes over 5-7year period for Proper Motions.

'Y' is a 'long Z' filter sampling a peak in the spectral energy distribution of cool brown dwarfs at 1.05 μm. (Y-J) distinguishes early T dwarfs from late M and L dwarfs. (Y-J) may also provide temperature information with less dependence on metallicity, dust and rotation speed than (J-H) and (J-K). A (Y-J) selection also finds the brightest z=7-8 Quasars.

Total Depth: Y=20.5, J=20.0, H=18.8, K=18.4 (5-σ, Vega system).

GPS: Equal time JH + 1.5× K observation of 1800 deg^2.

Covers half the Galactic plane from b=-5 to b=+5.

K band observations broken into 3 passes over a 5-7 year period, detecting proper motions and variability.

T dwarfs distinguished from O-F types by lack of extinctin and by proper motions. Ambiguity will remain in spectral typing in the M, L, and early T ranges in the JHK two-colour diagram.

Total Depth: J=20, H=19.2, K=19.0 (5-σ, Vega system).

GCS: Equal time JH + 2× K.

K band observation in 2 passes for proper motions.

Open Clusters: Alpha Per, Hyades, Pleiades, Praesepe, Coma-Ber, M39. IMF sampled to typically 30-40 M_{Jup}.

Star Formation Associations: Taurus-Auriga-Perseus (JHK+H_2), Orion, Scorpio-Centaurus. IMF sampled to typically 11-14 M_{Jup}.

Depth: J=19.6, H=18.8, K=18.8

5. Key Science from LAS, GPS, GCS

IMF in different clusters and environments.

Detection of brown dwarfs down to 400 or 500 K.

New spectral type beyond T-dwarfs?

Identify coolest candidates via Y band dropouts with large proper motions.

Will these objects have liquid water droplets in the upper atmosphere?

Locate planetary mass 'sub-brown dwarfs' (5-10 M_{Jup} in the Solar Neighborhood.

Probe L-dwarf population to several hundred pc and kinematics to > 100 pc.

Contacts

LAS: Richard Jameson, University of Leicester (rfj@star.le.ac.uk)

GPS: Phil Lucas, University of Hertfordshire (pwl@star.herts.ac.uk)

GCS: Nigel Hambly, Royal Observatory, Edinburgh (nch@roe.ac.uk).

Acknowledgments. This poster paper is a summary of the plans of the UKIDSS consortium, which has members in many UK universities and strong links with the VISTA consortium.

References

Casali, M.M. 2001: www.roe.ac.uk/atc/projects/wfcam/index.html