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PATT2
Version 08/99

APPLICATION FOR TELESCOPE TIME (OPTICAL AND INFRARED)

1 TELESCOPE *Specify one of AAT,WHT,INT,JKT,UKIRT*	INT
2 SEMESTER	2000A

Reference: Date Stamp:

3 PRINCIPAL APPLICANT

Surname: McMahon Title: Dr Initials: R.G
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4 COLLABORATORS

Name:	Institute:	Observer?
P. Hewett, C. Mackay, I. Parry, C. Sabbey	Institute of Astronomy	Yes
S. Hodgkin, M. Irwin, J. Lewis	Astronomical Survey Unit, Institute of Astronomy	Yes
N. Walton	Isaac Newton Group	

5 SHORT TITLE OF PROPOSAL *(maximum 12 words)*

A Public Near IR imaging survey on the INT

6 SUMMARY OF PROPOSED OBSERVATIONS

We propose to carry out a major **public** wide field near IR imaging survey on the INT using the Cambridge Infra Red Survey Instrument(CIRSI). CIRSI is an innovative JH-band, wide field, IR camera built by Mackay, McMahon and Parry using a mosiac of 4 Rockwell 1024^2 HgCdTe arrays. With an instantaneous field of view of 15.6'x15.6' CIRSI is the largest IR camera in existence. We propose to initiate this wide field near IR survey program on the INT in semester 2000A with a survey in J and H band over $\sim$25deg^2 to J=20.5; H=19.1($\sim$3.5magnitudes fainter than 2MASS) with the aim of extending the survey to 50deg^2 or to fainter limits in 2001A. Even with this modest investment of telescope time we sample a 'local' volume $\sim$10% that of 2MASS, albeit 20 times fainter. This proposal is intended as part of a strategic program aimed at enhancing the UK's use of Gemini N and S and the amount of follow-up using highly sought after 4m and 8m class telescope time will quickly exceed the INT request.

7 FOCAL STATION, INSTRUMENT AND DETECTOR

Focal station:	Instrument:	Detector(s):	Gratings/Filters:
Prime	CIRSI	4 Rockwell 1024^2	J,H

8 OBSERVING TIME REQUESTED THIS SEMESTER

	Dark:	Grey:	Bright:	specify nights *or* weeks:
Time requested this semester			14	N
Minimum useful allocation this semester			10	

UKIRT applicants requiring dark time must justify this in section 16

9 COMPLETE THIS SECTION ONLY IF THIS IS A LONG TERM PROPOSAL

	Dark:	Grey:	Bright:	specify nights *or* weeks:
Total time requested			28	N

Justification for long term status must be given in section 15

10 SCHEDULING INFORMATION

Preferred dates:	May-June
Impossible dates:	Feb, Mar, Jul
Give justification for impossible dates	Instrument unavailable
If observations are to be simultaneous with other telescopes or satellites, give details:	
Any other scheduling constraints: *Include likely clashes with other time applications, constraints on lunar position or quarter, instrument preparation requirements, etc*	

11 SERVICE OBSERVING

yes: [ ] no: [x] maybe: [ ]

12 SUPPORT ASTRONOMER REQUESTED AT TELESCOPE

every night: [ ] no: [ ] first night only: [x]

13 LIST OF PRINCIPAL TARGETS

Object(s): RA(h,m): Dec(degs): Mag(type): Colour: Exp. Time:

Fields	RA (J2000)	Dec	Field size	bands	Exp. Time	notes
NGC Equatorial Strip	$10 < \alpha < 15$	± 0.25	$75^\circ \times 0.5^\circ$	J,H	300secs	FIRST
WFSJ1610+54	16 10.0	+54 30	$3^\circ \times 3^\circ$	J,H	300secs	ISO-ELAIS, FIRST
16 XMM fields	$10 < \alpha < 16$	$\delta > -10$	$0.5^\circ \times 0.5^\circ$ each	J,H	300secs	FIRST

14 LIST ALL SIMILAR/SUPPORTING APPLICATIONS TO ANY PATT OR OTHER TIME ASSIGNMENT COMMITTEE

You must include a brief description of any other applications whose targets or science goals are similar to those requested here

Telescope/satellite:	Title/Description of programme:
INT	XMM related proposal by Watson

Introduction Astronomy is an observational science, and quantitative surveys form a basic foundation of the subject. Without systematic, quantitative, unbiased surveys our subject will stagnate. The strategic value of such surveys is epitomised in plans for the UKIRT Wide Field upgrade and the VISTA JIF award. However, these programs are many years off. Recognising the obvious need for wide field IR surveys, the Institute of Astronomy, Cambridge has invested £600k in the development of CIRSI an innovative wide field JH-band IR camera built around a mosaic of 4 Rockwell 1024^2 HgCdTe arrays. While, most of the year CIRSI is now based at the DuPont 2.5m in Chile, where the scientific emphasis is on deep IR surveys we are also keen to devote some time to the Northern Hemisphere and to carry out shallower surveys.

Rather than embark on piecemeal small proposals, we propose to carry out a major moderate depth IR survey on the INT. CIRSI has now reached a stable operating level and it is therefore timely to embark on a major wide field public IR survey where reduced data products are made public via the ING archive on a 3-6month timescale after observations take place. This survey shall be carried out in regions that have extant optical CCD data from the INT WFS project(McMahon etal, 1999). Below we summarise some science themes that are the focus of the proposers.

Cool White Dwarfs Microlensing results suggest that 50% of the Halo dark matter may be explained in 0.5 $M_\odot$ objects (with a number density of 0.0079 pc^3, Richer et al. 1999). Cool white dwarfs are an obvious candidate, especially following the calculation of new model atmospheres (Hansen 1998) which show that they are blue in colours such as I–H, but red in g–r. We will search for objects with this trademark signature (Hodgkin et al. 1999), and provide a direct measurement of the space density of cool white dwarfs. If they are to explain the Halo dark matter then we expect to find ~ 20 cool white dwarfs in our survey. Figure 1 shows the optical-IR spectrum of the cool white dwarf WD0346+46. Note the distinctive optical and IR colours.

Low mass stars and brown dwarfs Brown dwarfs (BDs) are the most numerous stars in the Galaxy, although their mass contribution is only around 10% (Reid et al. 1999). One of the most remarkable discoveries of the last year has been the almost simultaneous discoveries by DENIS, 2MASS and Sloan surveys of the first local BDs with the discovery of 5 T (Methane) dwarfs ($T_e \leq 1200$ K, Burgasser et al. 1999) and 25 L dwarfs ($1200 \leq T_e \leq 2000K$, Reid et al. 1999). However the remarkable detection of a T dwarf in the ESO deep imaging survey within a volume of only 1 pc^3 (Cuby et al. 1999) suggests a density 100 times higher for T dwarfs. With this proposal we can find T dwarfs out to >100 pc and test the ESO result. If the *very local* 2MASS volume is representative, then we will find ~ 25 T dwarfs. If it transpires that the local volume is biased (as implied by the ESO result) then we will find many more. We shall also be able to search for L dwarfs later than L8, and T dwarfs cooler than Gliese 229B ($T_e \sim 900$K; Figure 2).

Reddening independent selection of quasars and the neutral gas content of the Universe Storrie-Lombardi, McMahon and Irwin(1996a) have recently shown via the study of damped Lyman-α absorption systems(log(N(HI)>20.3) superposed on the spectra of distant quasars that over the redshift range 2<z<4, the total mass in neutral gas is comparable with the total visible mass in stars in present day galaxies and that the volume density is constant over the redshift range 2 to 4(see Figure 3). The simplest interpretation is that over the redshift range 2 to 4, we are observing the assembly of disk galaxies. However, the use of quasar absorption lines in this manner has been severely critised by Fall & Pei(1995) since optical samples are biased against lines of sight that may contain gas rich dusty galaxies. The only way to unambiguously ascertain whether there is a problem in such work is to select quasars at IR wavelenghts. Figure 4 shows how we can select quasars using optical and IR colours. The predicted surface density of QSOs with z>2 and H<18.5 is 5-10deg^2 and thus in 50deg^2 we expect 250-500 QSOs with z>2. Based on the work of Storrie-Lombardi, Irwin & McMahon(1996b) the number density of damped Lyman-α(DLA) is dN/dz $\sim$0.1 and thus 25-50 DLA systems should be detected and thus sufficient(ie $N/\sqrt{N} \sim 5$) to compare with previous samples detected via optically selected quasars.

Give details of the technical feasibility of the proposal (S/N,etc) AND any non-standard technical requirements

Table 1 - CIRSI Characteristics on 2.5m INT

Pixel scale (arcsec/pixel)	0.46
FOV per chip	7.8' x 7.8'
effective FOV of mosaic	15.6' x 15.6'
FOV for 2x2 mosaic	29.6' x 29.6'
Frames/deg^2	16
Sensitivity(5σ in 1.2" seeing)	
J saturation time	90secs
H saturation time (sec)	45secs
J: 5mins	20.6
H: 5 mins	19.1

Table 2 - DENIS + 2MASS Characteristics

	2MASS	DENIS	**INT**	notes
Telescope diameter(m)	1.3	1.0	**2.5m**	
Exposure time	7.8secs	10.0secs	**300secs**	
Detectors	3 x 256^2	2 x 256^2	**4 x 1024^2**	
Pixel Size(arcsecs)	2x2	3x3	**0.46 x 0.46**	
Field of view	8.5'x8.5'	12.8'x12.8'	**15.6'x15.6'**	
Magnitude limits(5sigma)				
z	-	-	**22.1**	**INT WFS**
J	16.5	16.0	**20.6**	
H	15.8	-	**19.1**	
K	15.0	14.0	**-**	

Survey Parameters The survey design requirement are primarily driven by the requirement that all objects are within reach of current generation optical or near IR low resolution spectrographs on 4-8m class telescopes. The survey area is tempered by the requirement that we can process and deliver processed data within 3-6months of the data being acquired and by the requirement that statistically significant samples can be discovered in each of the science areas. H band is primarily required for the quasar program since we want to minimize the effect of reddening. The J band data is primarily driven by the low mass star program.

Time requirements Assuming 300secs per pointing split into 5 discrete dither positions and overheads for dithering, slewing, preread of 40%, it will take 500secs per pointing and 8000secs to cover 1deg^2. In a typical May night of 8.4hrs(time between twilight on 2000, May 15) we can survey 3.8deg^2. Thus in 7 nights, **with no allowance for bad weather** we can cover 26.6deg^2 to a H=19.1(5sigma) or J=20.6 in seeing of 1.2" the current INT 75% quartile value. We are therefore requesting 14nights in 2000A to survey 25deg^2 in both bands. In 2001A we shall request time to either double the area or to survey deeper in the same area.

Survey Area We plan to carry out the survey centred predomintly on the WFS survey zero declination strip and 1610+41 field. 20% of the survey will be carried out in survey fields that will be covered by XMM. The proposed allocation is constained by the availability of CIRSI on the INT and the amount of data that we believe we can process in a timely manner taking into account the requirement to also process the INT WFC data during the same period. All the survey areas are covered by the FIRST radio survey.

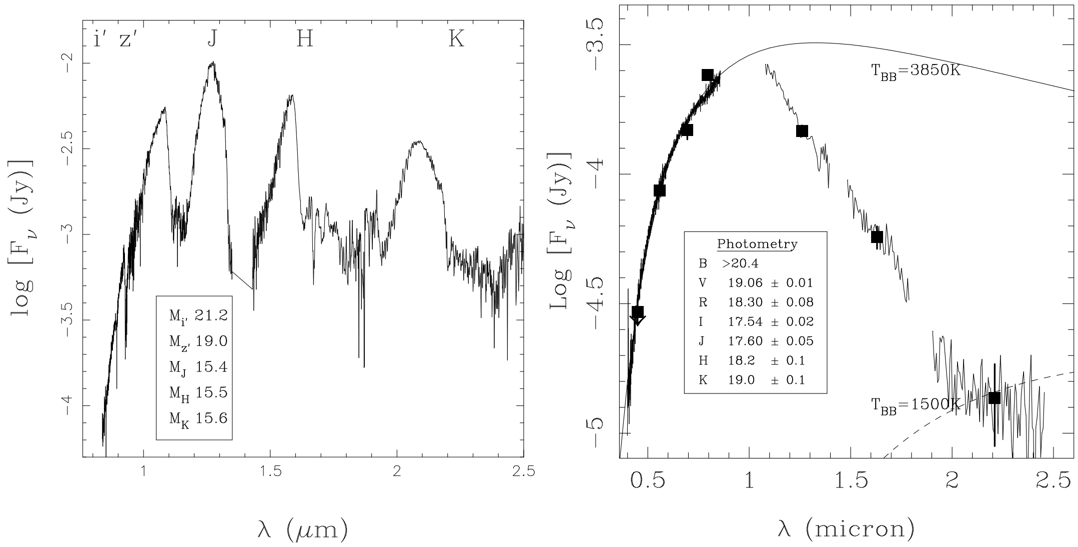

Figure 1,2: **Left Hand Plot:** The optical-infrared (Keck-UKIRT) spectrum of the T dwarf Gliese 229B showing the peak of the SED in the near infrared. Note the extreme red optical-IR colour; I−J=5.8 but blue IR colours; J−H **Right Hand Plot:** The 0.4-2.5 micron spectrum of the Halo white dwarf WD0346+246 showing the dramatic effects of collision induced absorption by H_2 in the infrared (Hodgkin et al. 1999). Thus the object appears *red* in the optical, but *blue* in the infrared. Two blackbody fits are overlaid at T=3850 K (solid curve) and T=1500 K (dashed curve). We derive T_e=3500 K for this object. Photometry is from UKIRT (IR) and the JKT (optical), whilst spectoscopy is from the WHT (optical) and the KECK (infrared).

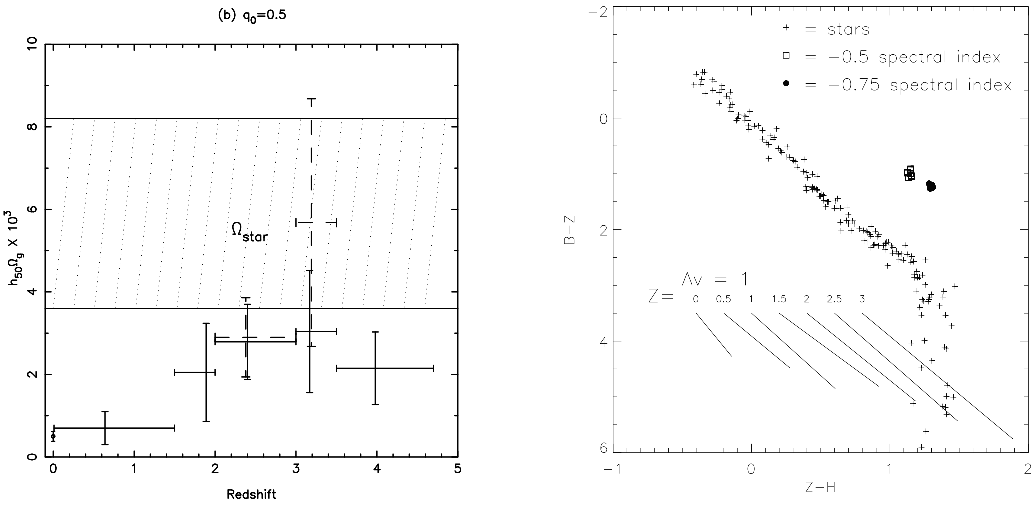

Figure 3,4; Left Hand Plot: From Storrie-Lombardi, McMahon & Irwin(1996a): The mean cosmological mass density in neutral HI, Ω_{HI}, contributed by damped Lyman-α absorbers for 0.01$\leq$z$\leq$4.7 for q_0=0.5. The region Ω_{star} is the $\pm\sigma$ range for the mass density in stars in nearby galaxies (Gnedin & Ostriker 1992). The point at z=0 is the local value (Fall & Pei 1993; Rao & Briggs 1993). **Right Hand Plot:** Simulated optical and near-IR colour-colour plot showing the locus of quasars compared with galactic stars from Gunn & Stryker 1983. Unlike the conventional purely optical colour-colour plots the redddeing vector does not drive the quasars into the stellar locus and hence we have a reddening independent technique for discovering quasars.

References

Fall, S.M. & Pei, Y.C. 1993, ApJ, 402, 479
Fall, S.M. & Pei, Y.C., 1995, ApJ, 454, 69
Gnedin, N.Y. & Ostriker, J.P. 1992, ApJ, 400, 1
Gunn & Stryker 1983 ApJS 52 121
Mobasher et al. 1986 MNRAS 223 11 Burgasser et al., 1999, ApJ, 522, L65
Cuby, J.G., et al., 1999, A&A, in press (astro-ph/9907028).
Hansen, B.M.S., 1998, Nature, 394, 860.
Hodgkin, S.T. etal,, 1999, Nature, submitted (email sth@ast.cam.ac.uk for a preprint).
Reid, I.N., et al., 1999, ApJ, in press (astro-ph/9905170)
Richer, H.B., Hansen, B.M.S., Limongi, M., Chieffi, A., Straniero, O., Fahlman, G.G., 1999, ApJ, in press (astro-ph/9908337).
Storrie-Lombardi, L.J., McMahon, R.G., Irwin, M. , 1996a, MNRAS, 283, L79-L83.
Storrie-Lombardi, L.J., Irwin, M.,, McMahon, R.G., 1996b, MNRAS, 282, 1330-1342.

17 SUMMARY OF BACKUP PROGRAMME FOR POOR OBSERVING CONDITIONS
If instrumentation or setup differs from main programme, give full details

Observations can be carried out in non-photometric conditions via the use of overlapping exposures

18 RELATED PATT APPLICATIONS OVER THE LAST FOUR SEMESTERS *(including unsuccesful applications)*

PATT reference:	Award:	Clear nights:	Comments:
I/98A/43	14Bn	50% useable	CIRSI shakedown period and as one might expect with a new instrument there were unexpected problems but these are all sorted out now and hence we are in the position to offer public access to CIRSI

19 PUBLICATIONS BASED ON PATT TIME PUBLISHED DURING THE LAST FOUR SEMESTERS *(maximum 6)*

(i) 'Discovery of a Supernova Explosion at Half the Age of the Universe and its Cosmological Implications', Perlmutter,S. et al,1998, Nature, 391, 89; **(ii)** 'A spectroscopic study of IRAS F10214+4724: a gravitationally lensed quasar and a relatively normal starburst galaxy', Serjeant, S, et al, 1998, MNRAS, 298, 321–331; **(iii)** 'Discovery of radio-loud quasars with z=4.72 and z=4.01', Hook, I.M., R. G. McMahon, R.G., 1998, MNRAS, 294, L7-L12; **(iv)** 'Towards Completing a Large Area ULIRG Survey', Clements, D.L., Saunders, W.J., McMahon, R.G., 1999, MNRAS, 302, 391; **(v)** 'Submillimetre observations of luminous z>4 radio-quiet quasars and the contribution of AGN to the submm source population', McMahon, Priddey, R, et al, MNRAS in press, astro-ph/9907239; **(vi)** McMahon with Sutherland et al, 'The power spectrum of the Point Source Catalogue redshift survey', 1999, MNRAS, 308, 289.

20 EXPERIENCE OF INTENDED OBSERVERS WHO HAVE NOT PREVIOUSLY USED THIS TELESCOPE

21 COMPLETE IF THE OBSERVATIONS ARE PRIMARILY FOR A STUDENT RESEARCH TRAINING PROGRAMME

Name of student:	
Project title:	

22 COMPLETE IF THE OBSERVATIONS ARE ASSOCIATED WITH A CURRENT PPARC/SERC RESEARCH GRANT

Name of principal investigator:	Dr P C Hewett
Grant title:	PATT Travel for the IoA
Grant number:	GR/J33319

23 NON-STANDARD TRAVEL AND SUBSISTENCE REQUIREMENTS *(UK observers only)*

Justify requests for travel and subsistence for more than one person:

CIRSI is a private non-common-user instrument and installation, astronomical operation and technical support is provided by the IOA Instrument team. We therefore we request PATT funding for a second observer as specified in our PATT rolling grant.

Details of any other expenditure (eg freight, remote observing):

Shipping to and from La Palma once per semester: £1800 as specified in our PATT rolling grant.

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