Particle Physics and Astronomy Research Council — **PATT2**
Polaris House, North Star Avenue, Swindon, SN2 1SZ — **Version 02/2000**
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APPLICATION FOR TELESCOPE TIME (OPTICAL AND INFRARED)

1 TELESCOPE *(AAT,WHT,INT,JKT or UKIRT)*	AAT	Reference:	Date Stamp:
2 SEMESTER	02A	3 SCIENTIFIC CATEGORY	2

4 RELATED PATT PROPOSALS *(this semester)*: *AAT:*☐ *WHT:*☐ *INT:*☐ *JKT:*☐ *UKIRT:*☐ *JCMT:*☐ *GEMINI:*☐ *LT:*☐ *MERLIN:*☐

5 PRINCIPAL APPLICANT

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6 COLLABORATORS

Name:	Institute:	Observer?

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

A deep, large-scale search for young brown dwarfs in the pre-main sequence cluster NGC2547

8 SUMMARY OF PROPOSED OBSERVATIONS

We propose to carry out a deep, large-scale photometric survey of the pre-main sequence (PMS) cluster NGC 2547, in order to identify a complete and homogeneous population of young brown dwarfs. Such PMS clusters, of ages 10-50 Myr, offer a good, and hitherto overlooked, opportunity in the search for brown dwarfs.
We plan to completely survey NGC2547 over 4 square degrees to identify candidate brown dwarfs by their location in an (i,i-z) diagram. A wide survey is needed to observe the spatial distribution of the whole population of brown dwarfs, which will yield clues to the process by which they form. Moreover, the same observations will allow the substellar mass function to be derived down to $\sim$20M_{Jup}. The proposed study will provide the first statistically robust census of brown dwarfs in a PMS cluster.

9 FOCAL STATION, INSTRUMENT AND DETECTOR

Focal station:	Instrument:	Detector(s):	Gratings/Filters:
prime	WFI	MIT/LL 8192^2	i,z

10 OBSERVING TIME REQUESTED THIS SEMESTER

	Dark:	Grey:	Bright:	specify nights *or* weeks:
Time requested this semester		3.5		Nights
Minimum useful allocation this semester		2.5		

UKIRT applicants requiring dark time must justify this in section 18

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

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

Justification for long term status must be given in section 17

Text fonts must *not* be smaller than the style-file defaults

12 SCHEDULING INFORMATION

Preferred dates:	Feb-Mar
Impossible dates: *Give justification for impossible dates*	Apr-Aug Target RA
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*	

13 SERVICE OBSERVING

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

14 SUPPORT ASTRONOMER REQUESTED AT TELESCOPE

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

15 LIST OF PRINCIPAL TARGETS

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

Name	α	δ	Epoch	Age	Distance	Radius	A_v
NGC2547	08 10.4	-49 10	2000	36 Myr	432 pc	25'	0.13 mag

16 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:
CFHT	Young brown dwarfs and the substellar mass function: clues to the star formation process A CFHT Key Program proposal has been submitted to perform similar large scale photometric surveys for young brown dwarfs in star forming regions, PMS clusters and in the Hyades, covering the whole age range 1-600 Myr. A number of promising PMS cluster targets are unobservable from CFHT, and such clusters have been poorly studied to date.

17 SCIENTIFIC JUSTIFICATION

Case not to exceed this A4 page. Figures and/or references can be included on page 4a

Most studies of the star formation process to date have dealt with the formation of *stellar* systems. With the recent discovery of brown dwarfs (BDs), with masses $<0.08M_\odot$, new perspectives have opened concerning the formation of condensed objects in molecular clouds.

Some of the most pressing issues are: How do substellar objects (SSOs) form? At what rate? What is the form of the substellar IMF? Is there a lower mass limit to the IMF? How do SSOs evolve with time? The first step to address these and other related issues is to identify complete, homogeneous SSO populations sampled in a variety of environments and at different ages.

The observational study of SSOs has seen spectacular development in recent years, with the detection of small but robust samples in star forming regions [1-4], young open clusters [5-8], and in the field [9,10]. Simultaneously, reliable models of the structure and atmospheres of SSOs were being constructed [11-13], allowing direct derivation of the physical properties of BDs from observational quantities. That BDs are found in widely differing environments suggests that their formation does not require specific conditions but is instead a part of the broader process of star formation.

Within this broad process there are two main competing scenarios for SSO formation. The first assumes that BDs form as stars do, from the gravitational collapse of individual low mass molecular cores. The supporting argument is that in the opacity limited regime the Jeans mass can be as low as a few M_{Jup} [14]. The second assumes that BDs are ejected protostellar embryos [15]. As a molecular cloud core collapses it fragments into a number of low-mass protostars, a dynamical system which rapidly decays, leading to the ejection of the lowest mass fragments. Ejected protostellar fragments are unable to accrete more mass and thus evolve as "free-floating" substellar objects. These two scenarios make distinctive predictions as to the dynamical evolution of SSOs, with strong implications for the interpretation of current estimates of the substellar IMF. If isolated BDs form as stars do, they will be expected to be spatially associated with young stars, and the IMF will be continuous across the stellar/substellar boundary. On the other hand, if BDs are born as ejected protostellar fragments, their high initial velocity ($\sim$1kms^{-1}, see [16]) will move them away from their birth site at a tangential drift rate of $\sim0.3^\circ$/Myr (at 140 pc). After a few $\times10^7$ yr, they would be found in a few degree radius halo around the cluster centre, which will in turn show an apparent deficit of SSOs.

Hence the aim of this proposal is to identify the complete BD population in the southern pre-main sequence (PMS) cluster NGC2547. This and other such clusters, with ages in the range 10-50 Myr, provide the best compromise for searching for SSOs. They are old enough for the molecular cloud to have disappeared, leading to low and uniform extinction. However they are sufficiently young that SSOs are still very bright and detectable down to low masses ($\sim20M_{Jup}$). Furthermore, the youth of these clusters ensures that little dynamical evolution (i.e. mass segregation) has yet occurred. The spatial distribution of SSOs in these clusters therefore directly reflects the conditions of their formation.

NGC2547 fulfils the criteria which optimize the detection of SSOs: distance $<\sim$400pc, age <50Myr, with a small spatial extent on the sky so that the whole cluster can be surveyed in reasonable time, and $b>10^\circ$ to reduce field star contamination. Of the small number of southern PMS clusters fulfiling these criteria, NGC2547 is a particularly compact, rich example.

This proposal is timely because clusters in the 10-50Myr age range have been hitherto largely overlooked and their stellar content poorly known (with the exception of IC4665, [17]). The compactness of NGC2547 will allow us to survey the entire cluster area and thus recover the complete stellar and substellar populations which, for a limiting magnitude of i$\sim$24, will reach down to masses near $0.02M_\odot$ ($20M_{Jup}$) (see Figure).

There is a clear need for **large scale** surveys of PMS clusters to sample the **entire** BD population and avoid biases in estimating the substellar IMF. The deep, large scale photometric survey proposed here aims at complete coverage of NGC2547. Observations of the spatial distribution of BDs will reveal which of the two competing formation scenarios outlined above has occurred. The observations will allow us to build a complete sample of the substellar population in NGC2547, and to derive the mass function down to the mass of superplanetary objects. Comparison with other data will test the universality, or otherwise, of the IMF in different PMS clusters, younger star forming regions and more evolved open clusters.

18 TECHNICAL INFORMATION (I)

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

We have selected NGC2547 from five southern PMS clusters which conform to the selection criteria outlined in §17, for observation in this proposal. Since the cluster radius given in §15 is derived from relatively massive stars (>1$M_\odot$), it is likely to be underestimated. We therefore require to survey a total of 4 sq. deg. around the cluster centre, i.e. a $2°\times2°$ field, corresponding to 16 33'×33' WFI fields.

Using the WFI direct imaging exposure time calculator, we find that for a limiting magnitude of i=23.8, S/N=7 is achieved in just under 30 min. We therefore request integration at i for 16 pointings × 30 min = 480 min. All 30 min exposures will be subdivided into 3 ×10 min as recommended (AAO Newsletter, Sep 2001). Including a 20% overhead for pointings and readout, plus the mandatory 33% overhead for poor weather, this totals 12.8 hr.

For observations at z, we request the same integration time for each 33'×33' field. At z, a target with i=z will yield 0.5 magnitudes less counts than at i. However since BDs are expected to have I-z∼ 1 (see Figure), we will perform half-hour (subdivided) exposures to reach z=23.3. Therefore the total time to be spent integrating at z is also 12.8 hr.

We would also like to perform short (60 s) exposures in both filters to characterise the low-mass *stellar* component of the cluster. We calculate these exposures will have limiting magnitudes i∼22 and z∼21.5 (S/N=7). Including overheads as above, this totals slightly less than 1 hr.
These short exposures will also allow us to avoid bright stars in the fields. Inspections of DSS plates reveal several nearby stars with V=5-6 and cluster stars with V<10. However on the red DSS plate, all these objects are much fainter. The very bright star γ Vel is further than 1° to the N and will not affect our survey.

All calculations assume grey time and the median 1.5 arcsec seeing. Integration time plus overheads as detailed above totals 26.6 hr, corresponding to ∼3.5 nights of 7.5 hr duration.

References

[1]. Briceno et al., 1998, AJ, 115, 2074
[2]. Luhman et al., 2000, ApJ, 540, 1016
[3]. Dougados et al., 2001, in prep.
[4]. Bejar et al., 2001, ApJ, 556, 830
[5]. Zapatero-Osorio et al., 1997, ApJ, 491, L81
[6]. Bouvier et al., 1998, A&A, 336, 490
[7]. Stauffer et al., 1998, ApJ, 499, L199
[8]. Barrado et al., 2001, ApJ, 546, 1006
[9]. Delfosse et al., 1999, A&AS, 135, 41
[10]. Kirkpatrick et al., 2000, AJ, 120, 447
[11]. Burrows et al., 1997, ApJ, 491, 856
[12]. Baraffe et al., 1998, A&A, 337, 403
[13]. Chabrier et al., 2000, ApJ, 542, 464
[14]. Low & Lynden-Bell, 1976, MNRAS, 176, 367
[15]. Reipurth & Clarke, 2001, AJ, 122, 432
[16]. Sterzik & Durisen, 1998, A&A, 339, 95
[17]. Prosser et al., 1993, AJ, 105, 1441

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

In the event of poor observing conditions we will concentrate on obtaining the required limiting magnitude in a small number of selected fields at increasing radial distance from the centre of NGC2547. Thus we will observe both the centre and the outer ragions of the cluster, enabling us to gain information on the spatial distribution of BDs throughout one sector of the cluster, and sample the mass function statistically.

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

PATT reference:	Award:	Clear nights:	Comments:

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

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

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

Name of student:	
Project title:	

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

Name of principal investigator:	
Grant title:	
Grant number:	

25 NON-STANDARD TRAVEL AND SUBSISTENCE REQUIREMENTS *(UK observers only)*
Justify requests for travel and subsistence for more than one person:

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

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