Science and Technology Facilities Council
Polaris House, North Star Avenue, Swindon, SN2 1SZ
Telephone 01793 442000 Fax 01793 442002

PATT2
Version 02/2013

APPLICATION FOR TELESCOPE TIME (OPTICAL AND INFRARED)

1 TELESCOPE *(AAT, UKST, WHT, INT or UKIRT)*	WHT	Reference:	Date stamp:
2 SEMESTER	2020B	3 SCIENTIFIC CATEGORY	4

4 COORDINATED PATT PROPOSALS — *AAT:*☐ *UKST:*☐ *WHT:*☐ *INT:*☐ *UKIRT:*☐ *JCMT:*☐ *GEMINI:*☐ *LT:*☐ *MERLIN:*☐

5 PRINCIPAL APPLICANT

Surname: Lintott Title: Prof First name: Chris

Post held: Professor of Astrophysics/Citizen Science Lead

Address:
University of Oxford
Department of Astrophysics, Denys Wilkinson Building
Keble Road, Oxford, OX1 3RH, UK

Telephone: 00441865273638 Fax:

E-mail: chris.lintott@physics.ox.ac.uk

Is the applicant a possible observer? Yes

6 COLLABORATORS

Name:	Institute:	Observer?
Dr Rebecca Smethurst	University of Oxford	Yes
Mr Tobias Geron	University of Oxford	Yes
Dr Brooke Simmons	Lancaster University	No

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

Are weak bars the progenitors of strong bars?

8 SUMMARY OF PROPOSED OBSERVATIONS

ABSTRACT NEEDED - CHRIS?

9 FOCAL STATION, INSTRUMENT AND DETECTOR

Focal station:	Instrument:	Detector(s):	Gratings/Filters:
f/11	ISIS	EEV12, RED+	R300B, R316R

10 OBSERVING TIME REQUESTED THIS SEMESTER

	Dark:	Grey:	Bright:	specify nights *or* weeks:
Time requested this semester	3			Nights
Minimum useful allocation this semester	3			

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				

12 SCHEDULING INFORMATION

Preferred dates:	January
Impossible dates: *Give justification for impossible dates*	Wrong RAs
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: [ ]

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:

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:

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

Understanding the role that internal processes play in galaxy evolution is a key goal of modern astrophysics. An increasing body of evidence shows that galaxy growth is mainly dependent on calm, secular processes rather than galaxy mergers; Kaviraj et al. (2012)[1], for example, have shown that only 27% of star formation is triggered by major or minor mergers. The focus has therefore shifted to trying to determine the dominant mechanisms responsible for galaxy growth and the quenching (or cessation) of star formation. One such process is the funneling of gas from the outskirts of a galaxy by a galactic-scale bar (REF). Bars are thought to remove gas needed for star formation in the outer regions and deposit it in the centre, where it either triggers a starburst or is too dynamically hot to be used for future star formation (REF). In either the case, the eventual result is that the galaxy has a lower star formation rate than before the formation of the bar, moving the galaxy from the blue cloud to the red sequence (see Figure 3).

One question that remains unanswered however is whether this only occurs in the strongest of barred galaxies, where the bar is the dominant feature. A large range of bar strengths are seen across the galaxy population with a broad distribution of bar lengths, widths and relative sizes (see Figure 2). Most previous studies have focussed their efforts on the strong bar population (REFS) which are easier to select from galaxy surveys since they are brighter and constitute the main feature of the galaxy. In contrast, there are a few studies which specifically target weaker bars to determine their effects on the galaxy (REFS). However, it is not known if weak and strong bars a continuous distribution of the same feature with similar effects or two separate phenomenon.

In this project we propose to observe a mass-matched sample ($0.01 < z < 0.05$; see Figure 1) of strong and weak bars along with a control sample of no bars in order to determine the impact of both strong and weak bars. We will use the ISIS spectrograph on the WHT to obtain spectra along and perpendicular to the bar for each target (unbarred galaxies will have the slit aligned along the major and minor axes). The flexibility provided by the choice of gratings makes ISIS the ideal instrument to achieve our science goals. Whilst the same science could be achieve with data from IFU surveys, such surveys do not allow for control over the sample, as they select a broad range of galaxies to broaden the science achievable. However, this reduces the resulting samples sizes of weak and strong bars beyond those which are statistically significant. Observations with ISIS will allow us to target a mass-matched sample of strong and weak bars across the colour-magnitude diagram and supplement the small number samples from IFU surveys such as MaNGA (Bundy et al. 2015[2]).

In particular, resolving the emission lines in each target across a large range of wavelengths with ISIS will allow us to determine the gas kinematics along and perpendicular to the bar. We aim to test whether there is a significant inflow of gas along the bar, compared to outside the bar (and compared to the control sample of unbarred galaxies) and therefore whether bars can indeed quench the star formation in a galaxy. Complementary to this we will test whether there is a significant difference in the gas kinematics of strong and weak bars in order to determine if weak bars are a separate phenomenon to strong bars, or part of a continuous distribution. We aim to definitely answer the question; do weak bars drive gas to the centre of a galaxy at the same or different rates to strong bars?

The simultaneous observation of both the blue and red side of the spectrum with ISIS will also allow us to determine the star formation rates within and outside the bar using $H\alpha$ on the red side, and $Dn4000\AA$ [OIII] on the blue side. These resolved star formation rates will be crucial to determining if the bar is indeed responsible for any change in the star formation rate in these galaxies. Once again we will also test the differences between the resolved star formation rates of strong and weak bars to determine whether both types of structures are able to quench the star formation in a galaxy.

We aim to publish two papers as a result of these observations: (1) determining the gas kinematics for each of our targets to determine which structures (if any) are inflowing gas to the centres and (2) constraining the star formation rates inside and outside of the bar to determine whether either strong or weak bars are directly responsible for quenching galaxies. With this work we aim to characterise the differing or similar effects of weak and strong bars to determine their overall contribution to galaxy evolution.

17 SCIENTIFIC JUSTIFICATION

Continuation page for AAT, WHT and UKIRT proposals for 8 or more nights, and for all long-term and coordinated proposals

18 TECHNICAL INFORMATION (I)

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

PARAGRAPH FROM TOBIAS ABOUT SAMPLE SELECTION.

The ISIS spectrograph on the WHT is ideal for observing this sample as it allows the simultaneous observation of the red and blue sides of the spectrum in combination with the felxibility of the gratings available. This allows us to optimise the wavelength range targetted against the spectral resolution in order to maximise the science output. We therefore propose to target the $H\alpha$ emission line in each of our sources with the R316B grating on the RED+ detector, with simultanous observations of the $D_n 4000\mathring{A}$ break-$H\beta$-[OIII] region ($5067 < \lambda_{emit} < 5250$) using the R300B on the EEV12 detector. Probing these regions of the spectrum specifically will allow us to observe a maximum number of emission lines to derive precise gas kinematics whilst also allowing for an accurate determination of the resolved star formation rate in and outside the bar.

In order to derive an accurate measure of the gas inflow rates in our targets, we need to be able to determine the gas kinematics. We will utilise the tried and tested PPXF spectral fitting code (Cappellari & Emsellem 2004[3]) to derive the velocity of the gas along the bar for each of our targets. To do this we require a high signal-to-noise ratio (SNR) to ensure that each of the emission lines in the sample are well resolved. To achieve a $SNR = 10$ for each of our targets we calculated an exposure time given the quantum efficiency of the detectors at the redshifted wavelegnth of $H\alpha$ ($6641 < \lambda_{emit} < 6681$) and assuming negligible sky background on dark sky nights with respect to the read noise of the EEV12 and RED+ detectors. Given these requirements the total on source time is ??? minutes, assuming a seeing of 1" and optimal airmass conditions. The minimum (maxmimum) exposure time for a single source is ?? (??) minutes.

Using this information combined with the overhead estimates from the ISIS Total Observing Time Estimator and assuming an average weather downtime of 34% in January, we calculate that we can observe all 30 targets in 3 nights of dark skies in January of the 2020 semester.

18 TECHNICAL INFORMATION (II)

References and Figures

[1] Kaviraj et al. 2013, MNRAS, 429, 40
[2] Bundy et al. 2015, ApJ, 798, 7
[3] Cappellari Emsellem, 2004, PASP, 116, 138

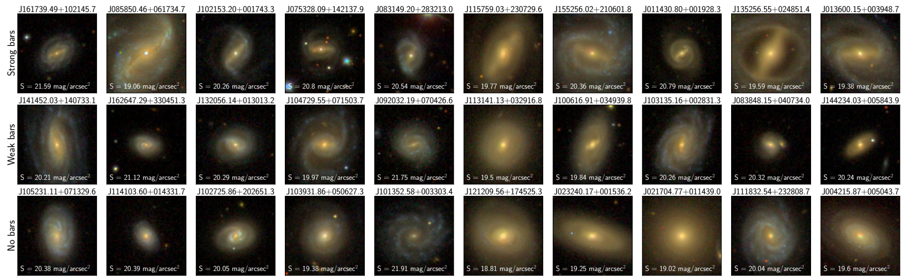

Figure 1: Mosaic of SDSS *ugriz* postage stamps of targets in this sample ($0.01 < z < 0.05$). The sample is split into strong bars (top), weak bars (middle) and no bars (bottom; our control sample) which are mass-matched along each column. The surface brightness of each source is also noted.

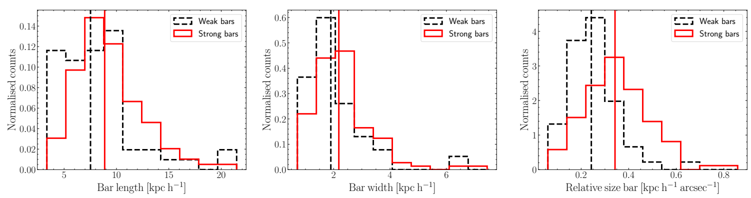

Figure 2: Distribution of the bar lengths (left), widths (middle) and relative size compared with the galaxy Petrosian radius(r-band; right) for the parent sample from which our targets were selected which have bar size measurements (REF). This figure shows that strong bars are distinct from weak bars, however this does not confirm whether they are distinct phenomenon. This proposal aims to test this hypothesis.

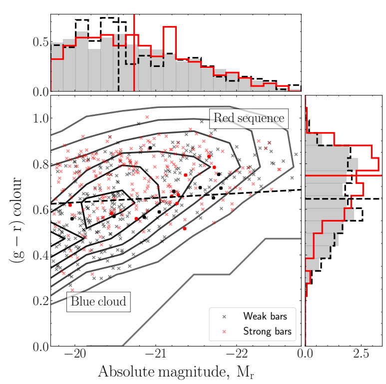

Figure 3: Colour magnitude diagram showing the locations of strong (red points and histogram) and weak (black points and histogram) bars in the parent sample. Filled circles show targets in this proposal. We also show the overarching distribution of galaxies in SDSS across this plane (black contours and grey histogram). We see a significant difference between the distribution of colours in strong and weak bars; with strong bars found preferentially on the red sequence (??%) and weak bars evenly distributed (??σ difference from the overarching SDSS galaxy population). We therefore aim to test the hypothesis that strong bars can cause the quenching of star formation, driving disc galaxies from the blue cloud to the red sequence, whereas weak bars can not.

19 SUMMARY OF BACKUP PROGRAMME FOR POOR OBSERVING CONDITIONS

If instrumentation or setup differs from main programme, give full details

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 STFC 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):