European Organisation for Astronomical Research in the Southern Hemisphere

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APPLICATION FOR OBSERVING TIME

PERIOD: **95A**

Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of CoIs and the agreement to act according to the ESO policy and regulations, should observing time be granted.

1. Title

Category: **D–3**

Spectropolarimetric observations of BRITE asteroseismic targets: a complete census of magnetic fields in bright stars up to V=4

2. Abstract / Total Time Requested

Total Amount of Time: 6 nights VM, 0 hours SM

This program aims at observing in circular spectropolarimetry all (yet unobserved) targets of the BRITE constellation of nano-satellites for asteroseismology, i.e. all stars brighter than V=4. They are mainly massive stars and evolved cool stars. Time has already been awarded at CFHT with ESPaDOnS and at TBL with Narval to observe the targets with a declination above -45°. We propose to observe 104 targets below -45° with HarpsPol. Time has already been allocated in P94 for 51 targets. We request here the remaining 53 targets. These data will allow us to (1) obtain a complete and unbiased census of magnetic fields of all stars brighter than V=4, (2) determine the fundamental parameters of all BRITE targets, to constrain the seismic models of BRITE observations; (3) discover new magnetic stars and thus constrain their seismic models even further. The BRITE magnetic targets are ideal targets to study stellar structure and mixing processes.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky	Mode	Type
A	95	HARPS	3n	apr	n	1.0	THN	v	
B	95	HARPS	3n	jul	n	1.0	THN	v	

4. Number of nights/hours

	Telescope(s)	Amount of time
a) already awarded to this project:	HARPS	3n in Nov 2014 + 3n in Mar 2015 (094.D-0274)
b) still required to complete this project:		

5. Special remarks:

Observations are also gathered at 2 other telescopes: (1) Narval@TBL (PI C. Neiner) concentrates on the 325 yet unobserved stars with dec > -20°. 10h were allocated in 2013B (under Director's discretion), 48h (36h executed) in 2014A (regular time): 97 targets were observed leading to 11 magnetic detections. 28h have been allocated for 2014B. ~60h will be requested for 2015. (2) ESPaDOnS@CFHT (PI G. Wade) concentrates on the 104 yet unobserved stars with -45° < dec < -20°. 11h were allocated in 2014A: 38 stars were already observed leading to 4 magnetic detections. 17h hours have been allocated for 2014B. 34h are requested for 2015.

6. Principal Investigator:

Coralie Neiner, coralie.neiner@obspm.fr, F, Observatoire de Paris,Site de Meudon

6a. Co-investigators:

E.	Alecian	Institut de Planetologie et d'Astrophysique de Grenoble (UMR 5274),F
A.	Blazere	LESIA,,F
M.	Briquet	Institut d'Astrophysique et de Geophysique,Universite de Liege,B
B.	Buysschaert	LESIA,,F

Following CoIs moved to the end of the document ...

7. Description of the proposed programme

A – Scientific Rationale: **The BRITE constellation of nano-satellites for seismology**
The BRITE (BRIght Target Explorer) constellation of nano-satellites monitors photometrically, in 2 colours, the brightness and temperature variations of stars with V≤4, with high precision and cadence, in order to perform asteroseismology. The mission consists of 3 pairs of nano-satellites, built by Austria, Canada and Poland, carrying 3-cm aperture telescopes. One instrument per pair is equipped with a blue filter; the other with a red filter. Each BRITE instrument has a wide field of view (∼24°), so up to 25 bright stars can be observed simultaneously, as well as additional fainter targets with reduced precision. Each field will be observed during several months. As of today, 5 nano-satellites are already flying and 4 are observing. Each pair of nano-satellites can (but does not have to) observe the same field and thus increase the duty cycle of observations.
BRITE primarily measures pressure and gravity modes of pulsations to probe the interiors and evolution of stars through asteroseismology. Since the BRITE sample consists of the brightest stars, it is dominated by the most intrinsically luminous stars: massive stars at all evolutionary stages, and evolved cooler stars at the very end of their nuclear burning phases (cool giants and AGB stars). Analysis of OB star variability will help solve two outstanding problems: the sizes of convective (mixed) cores in massive stars and the influence of rapid rotation on their structure and evolution. In addition, measurements of the timescales involved in surface granulation and differential rotation in AGB stars, cool giants and cool supergiants will constrain turbulent convection models. The Hertzsprung-Russell diagram of all stars with V≤4 is shown in Fig. 1.

Combining asteroseismology and spectropolarimetry
The study of the magnetic properties of pulsating stars is particularly interesting since, when combined with the study of their pulsational properties, it provides (1) a unique way to probe the impact of magnetism on the physics of non-standard mixing processes inside these stars and (2) strong constraints on seismic models thanks to the impact of the field on mode splittings and amplitudes.
The combination of an asteroseismic study with a spectropolarimetric study has been accomplished for only a couple of massive stars so far and these studies have been accomplished by our team, e.g. for the β Cep star V2052 Oph (Briquet et al. 2012, MNRAS, 427, 483). This star presents a magnetic field with a strength at the poles of about 400 G that has been modelled thanks to Narval spectropolarimetry (Neiner et al. 2012, A&A, 537A, 148). Moreover our asteroseismic investigations of this object showed that the stellar models explaining the observed pulsational behaviour do not have any convective core overshooting (Briquet et al. 2012). This outcome is striking because it is opposite to other results of dedicated asteroseismic studies of non-magnetic β Cep stars (e.g., Briquet et al. 2007, MNRAS, 381, 1482). Indeed, it is usually found that convective core overshooting needs to be included in the stellar models in order to account for the observations (Aerts, Christensen-Dalsgaard & Kurtz, 2010, "Asteroseismology", Springer). The most plausible explanation is that the magnetic field inhibits non-standard mixing processes inside V2052 Oph. Indeed the field strength observed in V2052 Oph is above the critical field limit needed to inhibit mixing determined from theory (e.g. Zahn 2011, IAUS 272). Our findings opened the way to a reliable exploration of the effects of magnetism on the physics of mixing inside stellar interiors of main-sequence B-type pulsators.
Conversely, the deformation of line profiles by pulsations is usually neglected when modelling the magnetic field present in pulsating stars. However, these deformations directly impact the shape of the Stokes V signatures and thus our ability to derive correct magnetic parameters. We recently developed a version of the Phoebe 2.0 code that allows us to model both the line and Stokes V profiles at the same time, taking pulsations into account, thus presenting for the first time coherent spectropolarimetric models including magnetism and pulsations (see Neiner et al. 2014, IAUS 302, 302). Thanks to this work, and the combination of seismic and spectropolarimetric data, much more reliable magnetic parameters can be derived for pulsators.

B – Immediate Objective: **Observing program:** There are ∼600 stars brighter than V=4 including 108 stars with dec < -45°. Among these 108 stars, no very high-precision spectropolarimetric measurement exists for 104 stars. We propose to obtain one sensitive magnetic measurement (circularly polarised Stokes V spectra) with HarpsPol of each of these 104 stars over 2 semesters (P94 and P95). This corresponds to 61 intermediate- and high-mass stars (from O to F5) and 43 cooler stars. Time has already been allocated in P94 for 51 targets. We request here time for the remaining 53 targets. The first goal is to check whether these stars are magnetic. From the results of the MiMeS project (Wade et al. 2014, IAUS 302, 265), we know that ∼10% of all O and B stars are magnetic. A similar occurrence is found for A stars and down to F5. The magnetic fields observed in these stars are stable oblique dipoles of fossil origin, with surface strength at the poles from $B_{\rm pol}$ = ∼50 G to several kG. Therefore we will aim at detecting all fields above 50 G. For stars cooler than F5, the magnetic fields have a dynamo origin and ∼50% of them are found to be magnetic on average (see Petit et al., 2014, PASP 126, 469). The cool giants and supergiants, however, have very weak fields with $B_{\rm pol}$ of the order of a few to 10 G. Therefore for these stars, we will aim at detecting all fields above $B_{\rm pol} = 5$ G.
In addition, by combining the data acquired with HarpsPol with those obtained with ESPaDOnS and Narval, a complete spectropolarimetric census of bright (V≤4) stars will be available. We will use this database to perform detailed unbiased statistics on the presence of detectable magnetic fields in stars. The data will also be made available to the community as a legacy, through the PolarBase database (Petit et al., 2014, PASP 126,

7. Description of the proposed programme and attachments

Description of the proposed programme (continued)

469). Finally, all the spectra (whether the star is magnetic or not) will also serve to determine the fundamental parameters of the BRITE stars, needed for seismic modelling. For magnetic stars, chemical peculiarities may appear in the spectra and will be studied as well (e.g. Fossati et al. 2014, A&A 562A, 143).

Objectives: Thanks to the very high signal-to-noise spectropolarimetric observation of each target, we will:
(1) discover new magnetic stars. This is particularly crucial for massive stars, since only ∼65 magnetic OB stars are known as of today, including only a handful of pulsating massive stars (see Petit et al. 2013, MNRAS 429, 398). Statistically we expect to find ∼10% of magnetic stars among intermediate- and high-mass stars and 50% of magnetic stars among cooler stars. 14 new magnetic stars have already been discovered from the first Narval and ESPaDOnS observations. Note that one measurement is enough to detect a field as magnetic signatures appear in Stokes V profiles even for cross-over phases (i.e. when the longitudinal field is null).
(2) help select the best high priority targets for BRITE, i.e. the magnetic massive ones and the most interesting cool ones. BRITE can observe all ∼600 stars in 6 years if each field is observed 3 months on average, but it is useful to oberve the most interesting targets first or longer. In particular the BRITE sample includes 11 O stars, 160 B stars (including 29 known β Cep stars, 20 known classical Be stars, and 22 chemically peculiar B stars), 106 A stars (including 6 known Ap stars), 12 eclipsing binaries, 7 known δ Scuti stars, 7 HgMn stars, 3 RR Lyrae stars, 1 known roAp, 22 cool sub-giant stars, several dozens red giants,... Magnetic stars among them will be prime targets for asteroseismology.
(3) determine the fundamental parameters of all targets for the BRITE seismic modelling: effective temperature, gravity, projected rotation velocity (vsini), as well as abundances in particular for magnetic and chemically peculiar stars (HgMn, Ap, Am...).
(4) provide a complete spectropolarimetric census of bright (V≤4) stars, by combining the HarpsPol data with those we are already acquiring with ESPaDOnS and Narval as well as archival data.

Data analysis: The coIs of this proposal have extensive experience with optical spectroscopy, spectropolarimetry and seismology. Moreover, we have acquired and used large amount of HarpsPol data, e.g. during the MiMeS Large Program. Therefore we have experience in preparing and scheduling OBs, acquiring the observations, reducing them with dedicated software (e.g. REDUCE; Piskunov & Valenti 2002, A&A 385, 1095), analysing the data with appropriate and optimised tools (e.g. LSD), as well as interpreting and modelling the results (e.g. with ZDI, DoTS; Hussain et al. 2006, MNRAS 367, 1699).
The magnetic field will be diagnosed from the presence of Zeeman signatures in mean Stokes V line profiles extracted using Least-Squares Deconvolution (LSD; Donati et al. 1997, MNRAS 291, 658, Kochukhov & Wade 2010, A&A 513A, 13), with line masks tailored to the appropriate atmospheric parameters of each star and excluding emission lines. In the event of non-detections, the requested high-precision of our measurements will allow us to put strong constraints on the allowed undetected dipole field strengths, using the upper field limit determination tools that we already developed and used (e.g. Neiner, Monin et al. 2014, A&A 562A, 59).
Stellar parameters will be determined with appropriate codes depending on the required physics (winds, NLTE effects, Zeeman splitting,...) i.e. on the type of stars. In particular, we will use CMFGen (Hillier & Miller 1998, ApJ 496, 407) for O stars, Tlusty for B stars (Hubeny & Lanz 1995, ApJ 439, 875), Atlas9 (Kurucz 1993, KurCD 13) for cool stars, MARCS models (Gustafsson et al. 2008, A&A 486, 951) for the coolest stars, and Zeeman (Landstreet 1988, ApJ 326, 967) for the strongly magnetic stars.

Attachments (Figures)

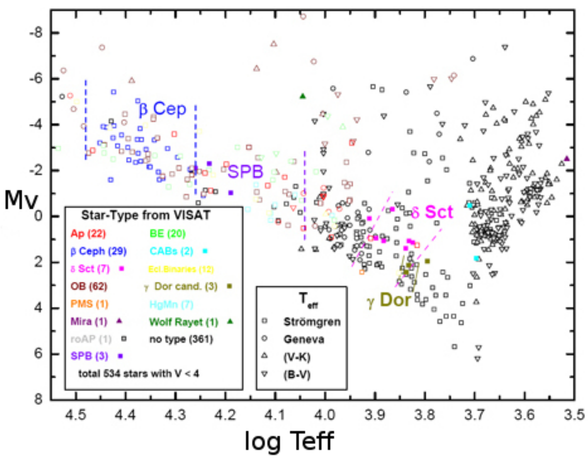

Fig. 1: Hertzsprung-Russell diagram of all stars with V<4, showing various categories of pulsating stars.

8. Justification of requested observing time and observing conditions

Lunar Phase Justification: The presence of the Moon will not affect our acquisition of spectropolarimetric data. We therefore have no restriction on the lunar phase for our observations.

Time Justification: (including seeing overhead) We fixed the magnetic field limit we plan to reach for fossil field stars (O to F5) to $B_{\rm pol} = 50$ G, since fossil fields usually detected in OB stars are between 50 G and a few hundred gauss and fields in A stars are stronger. For cool stars, however, the dynamo fields are much weaker and we fixed our detection limit to $B_{\rm pol} = 5$ G. In addition, the minimum singla-to-noise (SNR) in the intensity spectrum is fixed to 1000 to insure one high quality spectrum for each star.

The field detection limit that can be reached for a star depends on several parameters: (1) the peak SNR of the data, (2) the projected rotational velocity of the star (the uncertainty scales approximately as $(\mathrm{vsini})^2$), and (3) the number of lines available in the spectra that can be used in the LSD (Least Square Deconvolution) technique to extract the average Zeeman signature (often called the LSD gain), i.e. the spectral type of the star. Therefore we have tailored our exposure times to meet the required field limit for each star.

Each star will be observed only once, at any time when it is visible (i.e. there are no phase constraints). The required SNR has been estimated considering the spectral type and vsini of the star. Exposures time have been calculated using the Harps exposure time calculator in standard mode, applying a 1.5 time correction factor for the loss of light in fiber B, taking into account that we combine 4 subexposures to obtain one Stokes V measurement and considering the magnitude of the star, a seeing of 1.0 arcsec and an airmass of 1.3. The fast readout mode is used for all stars. When saturation is reached for the desired exposure time, observations are split into several successive sequences. Moreover, we have limited each measurement to a maximum of about 2 hours. This concerns 37 stars.

The total number of hours needed to observe all 104 (yet unobserved) stars with dec $<$ -45° is 79.3 hours. Including readout time, it amounts to 96.3 hours. 51 stars will be observed in P94. The remaining 53 stars are requested in P95 in 54.7 hours, i.e. 5.5 nights.

Taking into account the time for pointing, the time requested in this proposal for P95 is thus 6 nights. To be able to observe all stars in good airmass conditions, we request that this time be split in 2 runs of 3 nights each.

8a. Telescope Justification:

There are only 3 high-resolution spectropolarimeters available in the world (HarpsPol at ESO, ESPaDOnS at CFHT and Narval at TBL) capable of satisfying the aims of our program, i.e. to obtain sensitive measurements of magnetic fields in massive stars. Among these 3 instruments, HarpsPol is the only one available in the Southern hemisphere and thus the only instrument usable to measure the magnetic fields of the targets with a declination below -45°. Time has already been allocated on ESPaDOnS (PI G. Wade) and Narval (PI C. Neiner) to observe the other targets (dec $>$ -45°) of this program. Time has also already been allocated on HarsPol to observe the first half of our sample.

8b. Observing Mode Justification (visitor or service):

Only visitor mode observations are supported at La Silla.

8c. Calibration Request:

Standard Calibration

9. Report on the use of ESO facilities during the last 2 years

187.D-0917, PI Alecian, HarpsPol, MiMeS Large Program: observations completed and reduced, 4 papers published + 3 papers in preparation.
091.D-0090, PI Nazé, FORS2, on magnetospheres of hot stars: Nazé et al. 2014.
292.C-5044, PI Fossati, UVES, on the origin of chemical peculiarities in Am stars: Netopil, Fossati, et al. 2014.
292.D-5028, PI Shultz, Amber DDT, on xi^1 CMa: data acquired and analyzed, paper in preparation.
092.D-0587, PI Fossati, UVES, on circumstellar gas surrounding the WASP-17 and WASP-18 planetary systems: data collected, reduced and analysed, Fossati et al. 2014, Ap&SS in press + second paper in preparation.
293.D-5030, PI Fossati, UVES, on WASP-17: data collected, reduced and analysed, paper in preparation.
093.D-0448, PI Shultz, X-Shooter, on magnetospheric plasma in magnetic, massive stars: data under analysis.
093.D-0367, PI Grunhut, HarpsPol, on stellar mergers and magnetism in higher-mass stars: data acquired and analysed, paper in preparation.
094.D-0274, PI Neiner, HarpsPol, first part of the present project: observations are planned in November 2014 and March 2015.

9a. ESO Archive - Are the data requested by this proposal in the ESO Archive (http://archive.eso.org)? If so, explain the need for new data.

All stars brighter than V=4 already observed with either HarpsPol, ESPaDOnS or Narval with a sufficient SNR to reach the targeted magnetic field limit have been removed from our target list. There are 27 out of 108 stars with dec $<$ -45° already observed with HarpsPol in circular polarisation mode, but only 4 of them have been measured with sufficient precision to reach our science goals. Archival data will be used for those 4 stars to complete our census and we request observations for the other 104 stars.

9b. GTO/Public Survey Duplications:

There is no duplication of GTO and/or Public Survey programmes.

10. Applicant's publications related to the subject of this application during the last 2 years

Due to the large number of publications, only those of 2014 for which one the co-Is of the present proposal is the first author are listed below:

Alecian, Kochukhov et al., 2014, A&A 567, 28: Discovery of new magnetic early-B stars within the MiMeS HARPSpol survey – David-Uraz, Wade et al., 2014, MNRAS 444, 429: Investigating the origin of cyclical wind variability in hot, massive stars - I. On the dipolar magnetic field hypothesis – Fossati, Zwintz et al., 2014, A&A 562A, 143: Two spotted and magnetic early B-type stars in the young open cluster NGC 2264 discovered by MOST and ESPaDOnS – Grunhut, Bolton & McSwain, 2014, A&A 563, 1: Orbit and properties of the massive X-ray binary BD +60 73=IGR J00370+6122 – Lèbre, Aurière et al., 2014, A&A 561A, 85: Search for surface magnetic fields in Mira stars. First detection in χ Cygni – Kochukhov, Lüftinger et al., 2014, A&A 565, 83: Magnetic field topology of the unique chemically peculiar star CU Virginis – Neiner, Baade et al., 2014, Ap&SS tmp 292: UVMag: stellar formation, evolution, structure and environment with space UV and visible spectropolarimetry – Neiner, Monin et al., 2014, A&A 562A, 59: γ Pegasi: testing Vega-like magnetic fields in B stars – Neiner, Tkachenko and the MiMeS collaboration, 2014, A&A 563L, 7: Discovery of a magnetic field in the B pulsating system HD 1976 – Petit, Lignières et al., 2014, A&A 568, 2: The rapid rotation and complex magnetic field geometry of Vega – Petit, Louge et al., 2014, PASP 126, 469: PolarBase: A Database of High-Resolution Spectropolarimetric Stellar Observations – Shultz, Wade et al., 2014, MNRAS 438, 1114: An observational evaluation of magnetic confinement in the winds of BA supergiants – Wade, Folsom et al., 2014, MNRAS 444, 1993: A search for weak or complex magnetic fields in the B3V star iota Herculis – Weiss, Rucinski et al., 2014, PASP 126, 573: BRITE-Constellation: Nanosatellites for Precision Photometry of Bright Stars – Zwintz, Fossati et al., 2014, Science 345, 550: Echography of young stars reveals their evolution – Zwintz, Ryabchikova et al., 2014, A&A 567, 4: Refining the asteroseismic model for the young delta Scuti star HD 144277 using HARPS spectroscopy

11. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	rho Cen	12 11 39.12	-52 22 06.44	2.17	3.951			
A	del Cru	12 15 08.72	-58 44 56.14	1.95	2.775			
A	eps Cru	12 21 21.61	-60 24 04.13	0.11	3.59			
A	ACRUX	12 26 35.87	-63 05 56.58	2.02	1.4			
A	HR 4731	12 26 36.15	-63 05 57.14	1.99	1.55			
A	sig Cen	12 28 02.38	-50 13 50.29	2.13	3.897			
A	gam Cru	12 31 09.96	-57 06 47.57	0.12	1.63			
A	alf Mus	12 37 11.02	-69 08 08.03	1.88	2.677			
A	NLTT 31322	12 37 42.16	-48 32 28.69	1.87	3.852			
A	CCDM J12415-4858AB	12 41 31.04	-48 57 35.54	0.52	2.18			
A	CCDM J12463-6806AB	12 46 16.80	-68 06 29.22	2.02	3.07			
A	bet Cru	12 47 43.27	-59 41 19.58	0.37	1.297			
A	HR 4898	12 54 35.62	-57 10 40.52	0.83	3.988			
A	del Mus	13 02 16.26	-71 32 55.88	0.11	3.62			
A	eps Cen	13 39 53.26	-53 27 59.01	2.01	2.265			
A	zet Cen	13 55 32.39	-47 17 18.15	2.01	2.515			
A	bet Cen	14 03 49.41	-60 22 22.93	1.11	0.6			
A	iot Lup	14 19 24.22	-46 03 29.14	2.12	3.536			
A	alf TrA	16 48 39.90	-69 01 39.76	0.05	1.92			
A	alf Ind	20 37 34.03	-47 17 29.40	0.08	3.116			
A	HR 5460	14 39 35.06	-60 50 15.10	0.04	1.33			
A	alf Lup	14 41 55.76	-47 23 17.52	0.10	2.276			
A	alf Aps	14 47 51.71	-79 02 41.10	0.13	3.825			
A	CCDM J15051-4703AB	15 05 07.09	-47 03 04.50	2.05	3.89			
B	kap Lup	15 11 56.07	-48 44 16.17	1.85	3.849			
B	IDS 15050-4822 AB	15 11 57.2	-48 44 23	1.95	3.71			
B	zet Lup	15 12 17.10	-52 05 57.29	0.11	3.41			
B	gam TrA	15 18 54.58	-68 40 46.37	1.95	2.881			
B	LTT 6339	15 55 08.56	-63 25 50.62	0.31	2.85			
B	del TrA	16 15 26.27	-63 41 08.45	0.37	3.858			
B	gam Aps	16 33 27.08	-78 53 49.74	0.15	3.872			
B	eta Ara	16 49 47.16	-59 02 28.96	0.13	3.78			
B	zet Ara	16 58 37.21	-55 59 24.52	0.09	3.127			
B	bet Ara	17 25 17.99	-55 31 47.59	0.07	2.832			
B	gam Ara	17 25 23.66	-56 22 39.81	2.00	3.312			

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Target Notes: The stars listed above are the 53 targets for P95. 51 other stars will be observed in P94 in November 2014 and March 2015. Should any of these targets be observed with sufficient precision by another HarpsPol program prior to our observations, it would be dropped from our observations and archival data would be used.

12. Scheduling requirements

13. Instrument configuration

Period	Instrument	Run ID	Parameter	Value or list
95	HARPS	A	spectro-polarimetry	circular
95	HARPS	B	spectro-polarimetry	circular

6b. Co-investigators:

...continued from Box 6a.

A.	David-Uraz	Queen's University,CA
C.	Folsom	Institut de Planetologie et d'Astrophysique de Grenoble (UMR 5274),F
L.	Fossati	Argelander Institut fuer Astronomie,D
J.	Grunhut	ESO Headquarters Garching,ESO
G.	Handler	Nicolaus Copernicus Astronomical Center, Warsaw,PL
G.	Hussain	ESO Headquarters Garching,ESO
O.	Kochukhov	Uppsala University,Department of Physics and Astronomy,S
K.	Kubiak	Universitaet Wien,Institut fuer Astrophysik,AT
J.	Landstreet	The University of Western Ontario,Department of Physics and Astronomy,CA
A.	Lèbre	Laboratoire Univers et Particules de Montpellier,Universite Montpellier 2,F
A.	Moffat	Universite de Montreal,Departement de Physique,CA
J.	Morin	Laboratoire Univers et Particules de Montpellier,Universite Montpellier 2,F
M.	Oksala	LESIA,,F
P.	Petit	IRAP (Institut de Recherche en Astrophysique et Planetologie), UMR 5277,F
V.	Petit	Florida Institute of Technology,Department of Physics & Space Sciences,US
M.	Shultz	Queen's University,CA
G.	Wade	Royal Military College of Canada,Department of Physics,CA
W.	Weiss	Universitaet Wien,Institut fuer Astrophysik,AT
K.	Zwintz	Instituut voor Sterrenkunde,Katholieke Universiteit Leuven,B

11a. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
	...continued from box 11.							
B	del Ara	17 31 05.91	-60 41 01.85	2.07	3.6			
B	alf Ara	17 31 50.49	-49 52 34.12	2.04	2.836			
B	eta Pav	17 45 43.99	-64 43 25.94	0.11	3.597			
B	tet Ara	18 06 37.87	-50 05 29.31	2.01	3.663			
B	eps Pav	20 00 35.56	-72 54 37.82	2.00	3.95			
B	del Pav	20 08 43.61	-66 10 55.44	0.12	3.56			
B	PEACOCK	20 25 38.86	-56 44 06.32	0.07	1.91			
B	bet Pav	20 44 57.49	-66 12 11.57	0.61	3.426			
B	bet Ind	20 54 48.60	-58 27 14.96	0.12	3.658			
B	HR 8254	21 41 28.65	-77 23 24.16	0.12	3.76			
B	alf Gru	22 08 13.98	-46 57 39.51	2.00	1.74			
B	alf Tuc	22 18 30.09	-60 15 34.53	0.07	2.86			
B	eps Gru	22 48 33.30	-51 19 00.70	2.10	3.489			
B	bet Hyi	00 25 45.07	-77 15 15.29	0.07	2.8			
B	zet Phe	01 08 23.08	-55 14 44.73	2.17	3.967			
B	ACHERNAR	01 37 42.85	-57 14 12.31	1.98	0.5			
B	bet Gru	22 42 40.05	-46 53 04.48	0.15	2.13			
B	iot Gru	23 10 21.54	-45 14 48.16	0.14	3.89			