OBSERVING PROGRAMMES OFFICE • Karl-Schwarzschild-Straße 2 • D-85748 Garching bei München • e-mail: opo@eso.org • Tel.: +49 89 320 06473

APPLICATION FOR OBSERVING TIME

PERIOD: **94A**

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. 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	94	HARPS	3n	dec	n	1.0	THN	v	
B	94	HARPS	3n	feb	n	1.0	THN	v	

4.

Number of nights/hours	Telescope(s)	Amount of time
a) already awarded to this project:		
b) still required to complete this project:	HARPS	5n

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°. 10 hours were allocated in 2013B (under Director's discretion): 52 targets were observed including 3 magnetic detections. 48h were allocated in 2014A and these observations just started. Additional time will be allocated for 2014B. (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 including 4 magnetic detections. 51 additional hours are requested in total for the upcoming 3 semesters.

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
A.	David-Uraz	Queen's University,CA

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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 will monitor photometrically, in 2 colours, the brightness and temperature variations of stars with V$\leq$4, with high precision and cadence, in order to perform asteroseismology. The mission consists of 3 pairs of nano-satellites, built respectively by Austria, Canada and Poland, carrying 3-cm aperture telescopes. One instrument per pair is equipped with a blue filter; the other with a red filter. Each BRITE instrument has a wide field of view ($\sim$24°), so up to 25 bright stars can be observed simultaneously, as well as additional fainter targets with reduced precision. Each field will be observed during several months. The first 2 nano-satellites (from Austria) were launched on 25 February 2013 and observations started in September after a technical commissioning phase. The first Polish nano-satellite was launched on 21 November 2013, the second one will be launched in April 2014, and observations will start this summer. The launch of the 2 Canadian nano-satellites is currently foreseen for mid-2014. Each pair of nano-satellites can (but does not have to) observe the same field and thus increase the duty cycle of observations. BRITE will primarily measure pressure and gravity modes of pulsations to probe the interiors and evolution of stars through asteroseismology. Since the BRITE sample consists of the brightest stars, it is dominated by the most intrinsically luminous stars: massive stars at all evolutionary stages, and evolved cooler stars at the very end of their nuclear burning phases (cool giants and AGB stars). Analysis of OB star variability will help solve two outstanding problems: the sizes of convective (mixed) cores in massive stars and the influence of rapid rotation on their structure and evolution. In addition, measurements of the timescales involved in surface granulation and differential rotation in AGB stars, cool giants and cool supergiants will constrain turbulent convection models. The Hertzsprung-Russell diagram of all stars with V$\leq$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 from the Stokes V profiles. However, the pulsation 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 the line profiles, taking pulsations into account, and the Stokes V profiles at the same time, thus presenting for the first time coherent spectropolarimetric models including magnetism and pulsations (see Neiner et al. 2013, arXiv 1311.2262). 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 $\sim$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. The first goal is to check whether these stars are magnetic.

From the results of the MiMeS project (Wade et al. 2013, arXiv:1310.3965), we know that $\sim$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 strength at the poles from $B_{\rm pol}$ = $\sim$50 G to several hundreds G. Therefore we will aim at detecting all fields above 50 G. For stars cooler than F5, the magnetic fields have a dynamo origin and $\sim$50% of them are found to be magnetic on average (see Petit et al., 2014,

7. Description of the proposed programme and attachments

Description of the proposed programme (continued)

A&A, arXiv:1401.1082). 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, when combining the data acquired with HarpsPol with those obtained with ESPaDOnS and Narval, a complete spectropolarimetric census of bright (V$\leq$4) stars will then be available. We will use this database to perform detailed unbiased statistics on the presence of magnetic fields in stars. These data will also be made available to the community as a legacy, through the PolarBase database (see Petit et al., 2013, A&A, arXiv:1401.1082). Finally, all the spectra (whether the star is magnetic or not) will also serve to determine the fundamental parameters of the BRITE stars, which are needed for seismic modelling. For magnetic stars, chemical peculiarities may appear in the spectra due to the presence of the field and will be studied as well (e.g. Fossati et al. 2014, A&A 562A, 143).

Objectives
Thanks to the one very high signal-to-noise (SNR) spectropolarimetric observation of each target, we will:
(1) discover new magnetic stars. This is particularly crucial for massive stars, since only $\sim$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 $\sim$10% of magnetic stars among intermediate- and high-mass stars and 50% of magnetic stars among cooler stars. 7 new magnetic stars have already been discovered from the first Narval and ESPaDOnS observations. Note that one measurement is enough to detect a field as magnetic signatures appear in Stokes V profiles even for cross-over phases (i.e. when the longitudinal field is null).
(2) help select the best high priority targets for BRITE, i.e. the magnetic massive ones and the most interesting cool ones. In particular the BRITE sample includes 11 O stars, 160 B stars (including 29 known β Cep stars, 20 known classical Be stars, and 22 chemically peculiar B stars), 106 A stars (including 6 known Ap stars), 12 eclipsing binaries, 7 known δ Scuti stars, 7 HgMn stars, 3 RR Lyrae stars, 1 known roAp, 22 cool sub-giant stars, several dozens red giants,... Magnetic stars among them will be prime targets for asteroseismology.
(3) determine the fundamental parameters of all targets for the BRITE seismic modelling: effective temperature, gravity, projected rotation velocity (vsini), as well as abundances in particular for magnetic and chemically peculiar stars (HgMn, Ap, Am...).
(4) provide a complete spectropolarimetric census of bright (V$\leq$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).

Attachments (Figures)

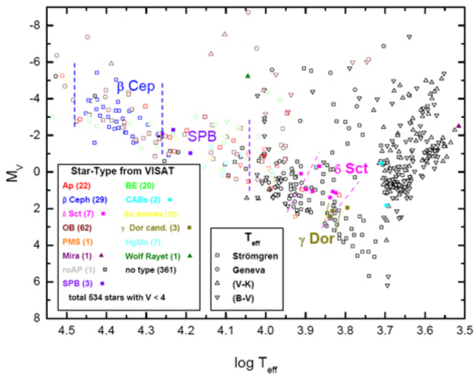

Fig. 1: Hertzsprung-Russell diagram of all stars with V<4, showing various categories of pulsating stars.

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 hundreds 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 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 can be observed in P94, corresponding to 41.6 hours, i.e. 5.2 nights. The remaining 53 stars will be 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 P94 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.

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: E. Alecian, HarpsPol, MiMeS Large Program: All observations are completed, all data have been reduced, 3 papers have been published, 1 submitted, 3 others are in preparation. The data will also be used in the series of MiMeS survey papers, which includes all data from the three MiMeS Large Programs (HarpsPol, ESPaDOnS and Narval).
090.D-0256, PI: O. Kochukhov, HarpsPol, Magnetic Doppler imaging of Ap stars in all four Stokes parameters. All observations are completed and reduced. Analysis is in progress. First paper from the project has been published. Several other publications are in preparation.
090.C-0131, PI: G. Hussain, HarpsPol and CRIRES, Magnetic fields in intermediate mass T Tauri stars: All data have been reduced. The magnetic field detections have been analysed and presented at two international conferences (e.g., Hussain & Alecian 2014 arxiv:1402.7130). First journal paper in preparation.
092.D-0587, PI: L. Fossati, UVES, Looking for circumstellar gas surrounding the WASP-17 and WASP-18 planetary systems: data collected, reduced and analysed. Paper in preparation.

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

Alecian, Neiner et al., 2013, A&A 549L, 8: The dramatic change of the fossil magnetic field of HD 190073: evidence of the birth of the convective core in a Herbig star? – Alecian, Wade et al., 2013, MNRAS 429, 1001+1027: A high-resolution spectropolarimetric survey of Herbig Ae/Be stars - I. Observations and measurements + II. Rotation – Briquet, Neiner et al, 2013, A&A 557L, 16: Discovery of a magnetic field in the CoRoT hybrid B-type pulsator HD 43317 – Folsom, Likuski et al., 2013, MNRAS 431, 1513: Orbital parameters, chemical composition and magnetic field of the Ap binary HD 98088 – Folsom, Wade & Johnson, 2013, MNRAS 433, 3336: Do the close binaries HD 22128 and HD 56495 contain Ap or Am stars? – Fossati, Kochukhov et al., 2013, A&A 551A, 85: Detection of a magnetic field in three old and inactive solar-like planet-hosting stars – 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, Wade et al., 2013, MNRAS, 428, 1686: Discovery of a magnetic field in the rapidly rotating O-type secondary of the colliding-wind binary HD 47129 (Plaskett's star) – Handler & Schwarzenberg-Czerny, 2013, A&A 557A, 1: Time-resolved multicolour photometry of bright B-type variable stars in Scorpius – Kochukhov, Alentiev et al., 2013, MNRAS 431, 2808: Discovery of new rapidly oscillating Ap pulsators in the UVES survey of cool magnetic Ap stars – Kochukhov, Makaganiuk et al., 2013, A&A 554A, 61: Are there tangled magnetic fields on HgMn stars? – Kochukhov, Mantere et al., 2013, A&A 550A, 84: Magnetic field topology of the RS CVn star II Pegasi – Kochukhov & Sudnik, 2013, A&A 554A, 93: Detectability of small-scale magnetic fields in early-type stars – Lèbre, Aurière et al., 2014, A&A 561A, 85: Search for surface magnetic fields in Mira stars. First detection in χ Cygni – Morin, Jardine et al., 2013, AN 334, 48: Multiple views of magnetism in cool stars – 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, Owocki et al., 2013, MNRAS 429, 398: A magnetic confinement versus rotation classification of massive-star magnetospheres – Shultz, Wade et al., 2014, MNRAS, 438, 114: An observational evaluation of magnetic confinement in the winds of BA supergiants – Zwintz, Fossati et al., 2013, A&A 552A, 68: Regular frequency patterns in the young δ Scuti star HD 261711 observed by the CoRoT and MOST satellites – Zwintz, Fossati et al., 2013, A&A 550A, 121: γ Doradus pulsation in two pre-main sequence stars discovered by CoRoT

11. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	LTT 63	0 9 24.64	-45 44 50.73	0.13	3.88			
A	bet Phe	1 6 5.04	-46 43 6.28	0.34	3.323			
A	LTT 827	1 31 15.10	-49 4 21.73	0.16	3.949			
A	HD 11937	1 55 57.47	-51 36 32.03	0.13	3.7			
A	LTT 1059	1 58 46.19	-61 34 11.49	0.77	2.9			
A	phi Eri	2 16 30.59	-51 30 43.80	2.11	3.545			
A	bet Ret	3 44 11.98	-64 48 24.86	0.13	3.85			
A	gam Hyi	3 47 14.34	-74 14 20.27	0.27	3.24			
A	alf Ret	4 14 25.48	-62 28 25.89	0.10	3.343			
A	alf Dor	4 33 59.78	-55 2 41.92	0.81	3.256			
A	bet Dor	5 33 37.52	-62 29 23.37	1.37	3.77			
A	bet Pic	5 47 17.09	-51 3 59.44	2.09	3.861			
A	Canopus	6 23 57.11	-52 41 44.38	0.03	-0.72			
A	LTT 2656	6 48 11.46	-61 56 29.00	1.97	3.3			
A	tau Pup	6 49 56.17	-50 36 52.44	0.07	2.93			
A	HR 2736	7 8 44.87	-70 29 56.16	0.12	3.768			
A	del Vol	7 16 49.82	-67 57 25.75	1.18	3.976			
A	zet Vol	7 41 49.26	-72 36 21.96	0.14	3.96			
A	chi Car	7 56 46.71	-52 58 56.47	1.53	3.444			
A	gam Vel	8 9 31.95	-47 20 11.71	2.01	1.808			
A	eps Car	8 22 30.84	-59 30 34.14	0.16	1.953			
A	bet Vol	8 25 44.19	-66 8 12.81	0.12	3.775			
A	omi Vel	8 40 17.59	-52 55 18.80	0.15	3.63			
A	b Vel	8 40 37.57	-46 38 55.48	0.47	3.819			
A	del Vel	8 44 42.23	-54 42 31.75	1.69	1.95			
A	a Vel	8 46 1.64	-46 2 29.50	0.28	3.894			
A	c Car	8 55 2.83	-60 38 40.60	0.17	3.8			
A	c Vel	9 4 9.28	-47 5 51.85	0.12	3.756			
A	a Car	9 10 58.09	-58 58 0.82	0.18	3.4			
A	NLTT 21307	9 13 11.98	-69 43 1.95	1.39	1.7			
A	iot Car	9 17 5.41	-59 16 30.84	0.06	2.249			
A	kap Vel	9 22 6.82	-55 0 38.40	0.67	2.464			
A	N Vel	9 31 13.32	-57 2 3.76	0.08	3.179			
A	phi Vel	9 56 51.74	-54 34 4.04	0.30	3.45			
A	p Vel	10 37 18.14	-48 13 32.23	0.16	3.84			

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

Target Notes: The stars listed above are the 51 targets for P94. 53 other stars should be observed in P95. 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
94	HARPS	A	spectro-polarimetry	circular
94	HARPS	B	spectro-polarimetry	circular

6b. Co-investigators:

...continued from Box 6a.

P.	Degroote	Instituut voor Sterrenkunde,Katholieke Universiteit Leuven,B
C.	Folsom	IRAP (Institut de Recherche en Astrophysique et Planetologie), UMR 5277,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
T.	Moffat	Universite de Montreal,Departement de Physique,CA
J.	Morin	Laboratoire Univers et Particules de Montpellier,Universite Montpellier 2,F
M.	Oksala	Astronomical Institute AV CR,CZ
V.	Petit	West Chester University of Pennsylvania,Department of Physics,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.							
A	HR 4216	10 46 46.18	-49 25 12.92	0.09	2.721			
B	i Car	9 11 16.72	-62 19 1.13	2.03	3.947			
B	l Car	9 45 14.81	-62 30 28.45	1.96	3.4			
B	HR 3890	9 47 5.98	-65 4 19.09	0.09	2.96			
B	ome Car	10 13 44.22	-70 2 16.46	1.93	3.3			
B	V337 Car	10 17 4.98	-61 19 56.29	0.11	3.384			
B	HR 4102	10 24 23.71	-74 1 53.80	0.67	3.995			
B	s Car	10 27 52.73	-58 44 21.85	0.51	3.828			
B	p Car	10 32 1.46	-61 41 7.20	2.04	3.361			
B	tet Car	10 42 57.40	-64 23 40.02	1.94	2.78			
B	u Car	10 53 29.66	-58 51 11.42	0.13	3.79			
B	V382 Car	11 8 35.39	-58 58 30.14	2.11	3.923			
B	HR 4390	11 21 0.41	-54 29 27.67	2.09	3.9			
B	lam Cen	11 35 46.89	-63 1 11.43	1.94	3.117			
B	lam Mus	11 45 36.42	-66 43 43.54	0.44	3.634			
B	del Cen	12 8 21.50	-50 43 20.74	2.06	2.561			