Neiner 2014A_PNPS005

Spectropolarimetric observations of BRITE asteroseismic targets

Semester : 2014A **Science Cat. : Stars and stellar population**

Abstract

This proposal aims at observing in circular spectropolarimetry all (visible from TBL and yet unobserved) targets of the BRITE constellation of nanosatellites for asteroseismology. These targets are brighter than V=4, i.e. they are mainly massive stars, cool giants and AGB stars. These data will allow us to (1) determine the fundamental parameters of all BRITE targets, to constrain the seismic models of BRITE observations; (2) discover new magnetic stars, characterize their field and thus constrain the seismic models of BRITE observations further; (3) obtain coherent models of magnetic pulsating stars by taking pulsations into account in the magnetic modelling. The BRITE magnetic targets are thus ideal targets to study stellar structure and mixing processes.

Telescopes

Telescope	Observing mode	Instruments
TBL	service	Narval

Applicants

Name	Affiliation	Email	Country		Potential observer
Dr Coralie Neiner	Observatoire de Paris-Meudon (LESIA)	Coralie.Neiner@obspm.fr	France	Pi	
Bernard Leroy	LESIA, Paris-Meudon Observatory	bernard.leroy@obspm.fr	France		
Aurore Blazere	LESIA, Paris-Meudon Observatory	aurore.blazere@obspm.fr	France		
Evelyne Alecian	IPAG	evelyne.alecian@obspm.fr	France		
Stéphane Mathis	SAp/CEA	stephane.mathis@cea.fr	France		
Agnes Lebre	LUPM	Agnes.Lebre@univ-montp2.fr	France		
Maryline Briquet	Université de Liège + LESIA	maryline.briquet@ulg.ac.be	Belgique		
Pieter Degroote	Leuven University + LESIA	pieterd@ster.kuleuven.be	Belgique		

Applicants are continued on the last page

Contact Author

Title	Dr	***Institute***	Observatoire de Paris-Meudon
Name	Coralie Neiner	***Department***	LESIA
Email	Coralie.Neiner@obspm.fr	***Address***	5 place Jules Janssen
Phone(first)	0033145077785	***Zipcode***	92195
Phone(second)		***City***	Meudon
Fax	0033145077959	***State***	
		Country	France

Is this a long term proposal: Yes

This program is planned over 2 semesters as the BRITE targets cover the whole sky. We request 8.4 nights in 2014A and we will request 7.3 nights in 2014B.

Overall scheduling requirements

Most of the requested observations are unconstrained.

The follow-up of cool magnetic targets will require the data of each star to be acquired over ~2 weeks.

The 10 last measurements of the follow-up of massive magnetic stars will be phase-constrained.

Observing runs

run	telescope	instrument	time request (minimal)	moon	weather	mode	seeing	configuration	comments / constraints
A	TBL	Narval	3n (1n)	Bright	any	service	any	Observing mode: POL3 (polarimetry R=65000) Read-out mode : Fast	For 89 stars (in 2014A) with individual subexposure time below 120s.
B	TBL	Narval	6n (2n)	Bright	any	service	any	Observing mode: POL3 (polarimetry R=65000) Read-out mode : Normal	For 50 stars (in 2014A) with individual subexposure time above 120s.

Targets

Field	RA	Dec	Epoch	Exposure (sec.)	Runs	S/N	Red Magn.	Infrared Magn.	Diameter (arcsec)	ToO	Comments
HD145502	16:11:59.73	-19:27:38.5	J2000	1303	B	2000	4				B2IV
HD106625	12:15:48.37	-17:32:30.9	J2000	355	A	2000	2.59				B8III
HD157056	17:22:00.56	-24:59:58.3	J2000	651	B	2000	3.248				B2IV
GJ656.1B	17:10:22.70	-15:43:30.0	J2000	813	B	2000	3.5				A3V
HD174638	18:50:04.78	+33:21:45.6	J2000	834	B	2000	3.52				B8II-IIIep
HD85503	09:52:45.80	+26:00:25.0	J2000	220	A	1000	3.88				K2III
HD148856	16:30:13.19	+21:29:22.6	J2000	92	A	1000	2.786				G7IIIa
HD163917	17:59:01.59	-09:46:25.0	J2000	152	A	1000	3.309				G9III
HD141513	15:49:37.20	-03:25:48.7	J2000	852	B	2000	3.548				A0V
HD156283	17:15:02.83	+36:48:32.9	J2000	109	A	1000	3.156				K3II
BD+621161A	11:03:43.83	+61:45:04.0	J2000	42	A	1000	2.02				K1II-III
HD130841	14:50:52.71	-16:02:30.3	J2000	408	A	2000	2.753				A4IV-V
HD109379	12:34:23.23	-23:23:48.3	J2000	83	A	1000	2.65				G5II
HD171443	18:35:12.42	-08:14:38.6	J2000	205	A	1000	3.85				K3III
ADS9913A	16:05:26.23	-19:48:19.6	J2000	355	A	2000	2.59				B1V
HD150680	16:41:17.16	+31:36:09.7	J2000	101	A	1000	2.8				G0IV
HD98230J	11:18:10.90	+31:31:44.0	J2000	251	A	1000	3.79				G0V
HD168723	18:21:18.60	-02:53:55.7	J2000	133	A	1000	3.26				K0III-IV
HD184006	19:29:42.35	+51:43:47.2	J2000	1039	B	2000	3.769				A5V
HD144470	16:06:48.42	-20:40:09.0	J2000	1239	B	2000	3.946				B1V
HD98262	11:18:28.73	+33:05:39.5	J2000	149	A	1000	3.504				K3III
HD144284	16:01:53.34	+58:33:54.9	J2000	321	A	1000	4				F9V
HD116656J	13:23:55.54	+54:55:31.2	J2000	262	A	2000	2.27				A2V+A1m
HD110379	12:41:39.98	-01:26:58.2	J2000	764	B	2000	3.44				F0V

Targets are continued on the last page

Scientific Justification

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≤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 in each 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 15 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) have been launched on 25 February 2013, their technical commissioning phase is about to end and the scientific observations will start in a few weeks. The 2 Polish nano-satellites are planned to be launched on 21 November 2013 and in early 2014, and scientific observations will start ∼6 months later. The launch of the 2 Canadian nano-satellites is currently foreseen for the end of 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≤4 in 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 Fig. 2 and Neiner et al., IAUS 302, in press). Thanks to this work, and the combination of seismic and spectropolarimetric data, much more reliable magnetic parameters can be derived for pulsators.

Observing program

There are 371 stars brighter than V=4 visible from TBL (-25° < dec < 85°). They are shown in Fig. 3. In the TBL Legacy archive and CFHT archive at CADC, we found that 79 of these stars have already been observed with Narval in Stokes V and 44 stars have already been observed with ESPaDOnS in Stokes V, including 16 stars observed by both instruments. We propose to obtain 1 spectropolarimetric observation of all remaining stars with V≤4, visible from TBL, for which no spectropolarimetric observation is available yet. This corresponds to 264 stars, including 131 massive stars (from O to F4) and 133 cooler stars. The first goal is to check whether these stars are magnetic.

From the results of the MiMeS project, we know that ∼10% of all OB stars are magnetic. The same occurrence is found for A stars and down to F4 (i.e. all stars exhibiting a fossil field). For stars from F5 and cooler, the magnetic fields have a dynamo origin and nearly all stars will be found to be magnetic.

For the ∼13 massive stars for which a magnetic field will statistically be detected and for a selection of 13 cool stars which seem the most interesting, we will then follow-up the magnetic discovery with the acquisition of 20 additional measurements. Indeed, we have shown from tests with well studied magnetic stars for which many spectropolarimetric measurements are available that a strict minimum of 15 measurements, and preferably 20 measurements, well sampled along the rotation period, are necessary to recover the correct parameters of the magnetic field (Leroy et al., in preparation). With these time series we will then study the magnetic field configuration (strength and obliquity), as well as possible chemical peculiarities that may appear in the spectra due to the presence of the field. 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. In addition, a complete spectropolarimetric census of bright (V≤4) stars will then be available to the community as a legacy.

Objectives

Thanks to the one very high signal-to-noise spectropolarimetric observation of each target, we will:
(1) discover new magnetic stars
(2) help select the best targets for BRITE, i.e. the magnetic massive ones and the most interesting cool ones
(3) determine the fundamental parameters of all targets for seismic modelling
(4) provide a complete spectropolarimetric census of bright (V≤4) stars to the community for legacy

Thanks to the follow-up studies of magnetic stars, we will:
(1) characterise the magnetic strength and configuration of the newly discovered magnetic stars
(2) provide strong constraints on mixing, inclination angle and differential rotation for the seismic studies

Technical justification

We will observe Zeeman circular polarisation in spectral lines of each target, with Stokes V sequences divided into 4 subexposures. Exposures time have been calculated using the Narval exposure time calculator in spectropolarimetric mode, taking the magnitude and temperature of the star into account, assuming a seeing of 1.5 and an airmass of 1.5. Since BRITE targets have a magnitude V≤4, the fast readout mode will be used for all targets for which the individual subexposure time is below 120 s. This concerns all 133 cool stars and 38 massive stars. The normal readout mode will be used for the remaining 93 massive stars. Data will be reduced using the on-site Libre-ESpRIT reduction pipeline and analysed using the Least-Squares Deconvolution (LSD) technique as well as complementary techniques and scripts that we developed. Our team members have a great expertise with reducing, analysing, interpreting and modelling spectropolarimetric data, as well as with studying pulsating stars.

We will first acquire 1 measurement of each target with very high signal-to-noise (S/N). We will aim at S/N=2000 for hot stars, i.e. the maximum reachable S/N without saturation. For cool stars, we will aim at S/N=1000. Indeed, for cool stars, there are many more lines available in the spectra that can be used to extract the magnetic field information with LSD. Therefore S/N=1000 is sufficient. These high quality data will allow us to detect magnetic fields with error bars as low as 10 G on the longitudinal field strength, i.e. polar field strength down to ∼50 G.

Including readout time, the initial observations of all 264 stars will require 41.8 hours (5.2 nights) of telescope time. To calculate the telescope time needed for the follow-up, we used the average exposure time of hot and cool targets. The follow-up of all discovered magnetic massive stars will then require 64.3 hours (8 nights). The follow-up of 10% of the cool stars will require 19.2 hours (2.4 nights). The total time necessary for this program is thus 125.3 h, i.e. 15.7 nights. These observations will be spread over two semesters since the BRITE targets cover all right ascensions (see Fig. 4). For 2014A, we request 66.8 hours, i.e 8.4 nights, for 139 targets. The remaining 58.5 hours (7.3 nights), for 125 targets, will be requested in 2014B.

The initial observations requested for all targets are not phase-constrained. For magnetic massive stars requiring follow-up, the first ∼10 observations will also not be phase-constrained. Then a rotation period will be determined from these data and the subsequent ∼10 observations will have to be obtained at specific rotation phases to allow for a good coverage of the rotation period and a better reconstruction of the magnetic configuration. However, the magnetic field of massive stars being stable, each phase-constrained observation can be obtained at any rotation period, i.e. a large number of times during the semester. Therefore the phase constraints are not difficult to reach. For the follow-up of cool stars, since the magnetic fields have a dynamo origin, the observations will have to be acquired over a short period of time (∼2 weeks) for each target.

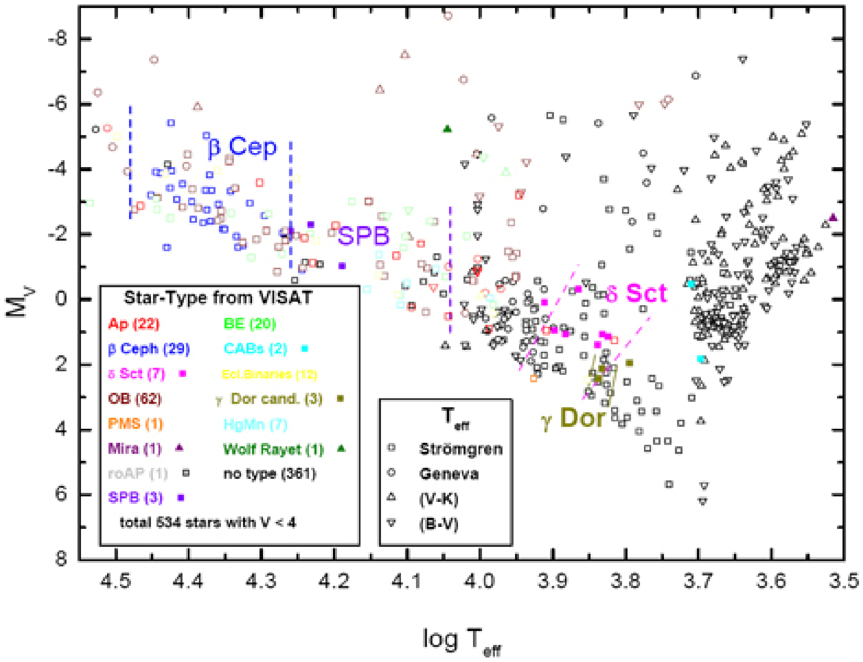

Figure 1: Hertzsprung-Russell diagram of all stars with V≤4, showing various categories of pulsating stars.

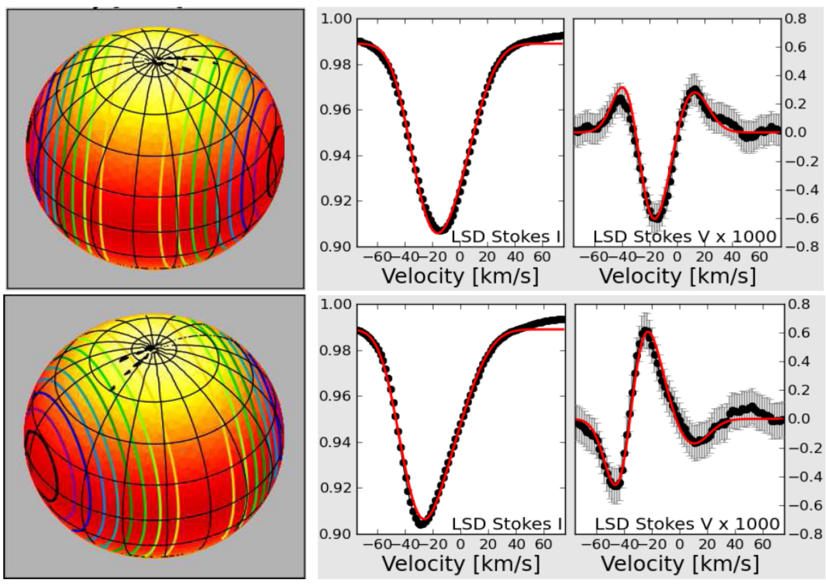

Figure 2: Examples of the modelled surface (left), LSD Stokes I (middle) and V (right) profiles of β Cep fitted with pulsations and magnetic field, at 2 different phases.

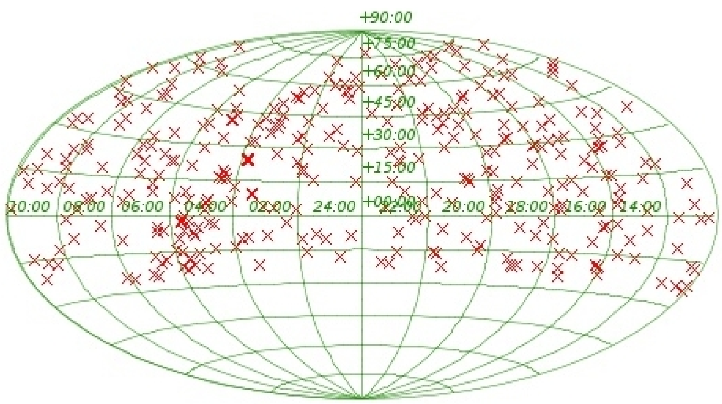

Figure 3: All 371 stars with V≤4 visible from TBL.

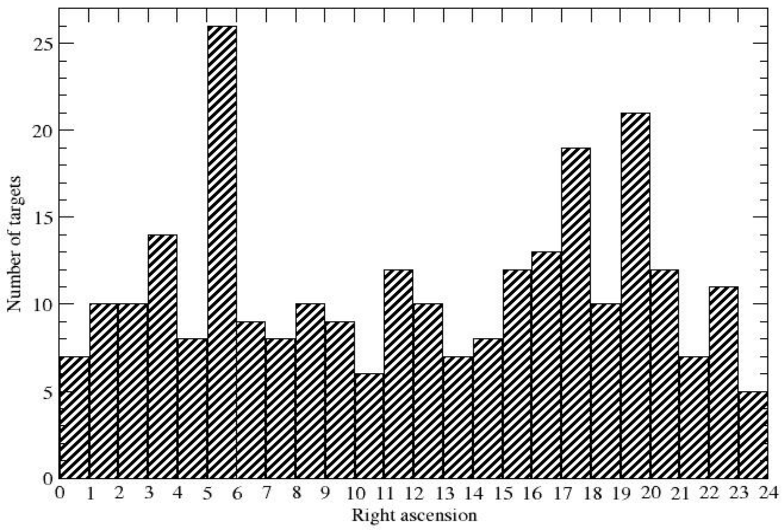

Figure 4: Distribution in right ascension of the 264 stars to be observed at TBL in this program.

Students involved

Student	Level	Applicant	Supervisor	Applicant	Expected completion date	Data required
Aurore Blazere	Doctor	Yes	Dr Coralie Neiner	Yes	2016/09	No

Linked proposal submitted to this TAC: No

Linked proposal submitted to other TACs: No

Justify the nights

In 2014A, we will obtain Stokes V observations of 139 targets: 69 hot stars and 70 cool stars. 89 of them have individual exposure time shorter than 120 s and we will use the fast readout mode; for the remaining 50 hot stars we will use the normal readout mode. Each target will first be observed once, with a peak S/N of 2000 for massive stars and 1000 for cool stars. The massive stars detected to be magnetic (~10% i.e. 7 stars) and 10% of the cool stars (i.e. 7 stars) will then be observed 20 times to fully characterize their field. We have used the average exposure time for each category of stars (hot and cool) to determine the time needed for this follow-up studies. In total for 2014A, including readout time, we request 66.8 hours of telescope time, i.e 8.4 nights.
Would the CS2M and TBL director allocate less time to our program, we would observe all stars once (2.8 nights) and perform only part of the follow-up studies. We would then request time in 2015 to complete our follow-up program.

Relevant previous Allocations: No

Additional remarks

This proposal is prepared in the frame of the GBOT (Ground-Based Observations Team) of BRITE, led by K. Zwintz with the support of the BRITE consortium.
Providing Narval observations of BRITE targets will allow members of the French community to access the seismic BRITE data (which is a project from Austria, Canada and Poland).

Related Publications

- M. Briquet, C. Neiner, B. Leroy, B., P.I. Pápics, 2013, A&A 557L, 16 : "Discovery of a magnetic field in the CoRoT hybrid B-type pulsator HD 43317"
- M. Briquet, C. Neiner, C. Aerts, T.Morel, S. Mathis, S. et al., 2012, A&A 427, 483 : "Multisite spectroscopic seismic study of the beta Cep star V2052 Ophiuchi: inhibition of mixing by its magnetic field"
- C. Neiner, P. Degroote, B. Coste, M. Briquet & S. Mathis, 2013, IAUS 302, in press : "Combining magnetic and seismic studies to constrain processes in massive stars"
- C. Neiner, S. Mathis, H. Saio, C. Lovekin, P. Eggenberger, P. & U. Lee, 2012, A&A 539A, 90 : "Seismic modelling of the late Be stars HD 181231 and HD 175869 observed with CoRoT: a laboratory for mixing processes"

Observing run info :

Run: A backup strategy: The targets are all bright (V<4). The brightest ones can be observed even in poor weather conditions by increasing accordingly the exposure time.
Run: B backup strategy: The targets are all bright (V<4). The brigthest ones can be observed even in poor weather conditions by increasing accordingly the exposure time.

Applicants

Name	Affiliation	Email	Country		Potential observer
Konstanze Zwintz	Leuven University	konstanze@ster.kuleuven.be	Belgique		
Gerald Handler	Nicolaus Copernicus Astronomical Center	gerald@camk.edu.pl	Pologne		

Targets

Field	RA	Dec	Epoch	Exposure (sec.)	Runs	S/N	Red Magn.	Infrared Magn.	Diameter (arcsec)	ToO	Comments
HD164058	17:56:36.36	+51:29:20.0	J2000	42	A	1000	2.23				K5III
HD79469	09:14:21.86	+02:18:51.3	J2000	1163	B	2000	3.88				B9.5V
HD163770	17:56:15.18	+37:15:01.9	J2000	222	A	1000	3.851				K1IIaCN+...
HD177756	19:06:14.93	-04:52:57.2	J2000	764	B	2000	3.427				B9Vn
HD161868	17:47:53.55	+02:42:26.2	J2000	1028	B	2000	3.75				A0V
HD89025	10:16:41.41	+23:25:02.3	J2000	767	B	2000	3.443				F0III
HD84441	09:45:51.07	+23:46:27.3	J2000	117	A	1000	2.975				G1II
HD191692	20:11:18.26	-00:49:17.3	J2000	645	B	2000	3.242				B9.5III
HD116657	13:23:56.33	+54:55:18.5	J2000	1157	B	2000	3.88				A1m
HD138905	15:35:31.57	-14:47:22.3	J2000	245	A	1000	3.925				K0III
HD123299	14:04:23.33	+64:22:33.0	J2000	961	B	2000	3.68				A0III
HD142860	15:56:27.18	+15:39:41.8	J2000	276	A	1000	3.84				F6IV
HD137759	15:24:55.77	+58:57:57.7	J2000	130	A	1000	3.31				K2III
HD177724	19:05:24.60	+13:51:48.5	J2000	509	B	2000	2.988				A0Vn
HD90432	10:26:05.42	-16:50:10.6	J2000	200	A	1000	3.833				K4III
HD121370	13:54:41.07	+18:23:51.7	J2000	91	A	1000	2.68				G0IV
HD155125	17:10:22.68	-15:43:29.6	J2000	304	A	2000	2.43				A2IV-V
HD159876	17:37:35.19	-15:23:54.7	J2000	840	B	2000	3.539				A9IIIpSr
HD178524	19:09:45.83	-21:01:25.0	J2000	461	A	2000	2.89				F2II/III
HD192577	20:13:37.90	+46:44:28.7	J2000	202	A	1000	3.79				K2II+...
HD138917	15:34:48.14	+10:32:19.0	J2000	1066	B	2000	3.79				F0
GJ9587A	17:10:22.68	-15:43:29.6	J2000	513	B	2000	3				A2V
HD100029	11:31:24.22	+69:19:51.8	J2000	136	A	1000	3.828				M0III
HD112185	12:54:01.74	+55:57:35.3	J2000	164	A	1000	1.76				A0p...
HD181276	19:17:06.16	+53:22:06.4	J2000	239	A	1000	3.8				G9III
HD187642	19:50:46.99	+08:52:05.9	J2000	67	A	2000	0.77				A7V
HD102224	11:46:03.01	+47:46:45.8	J2000	200	A	1000	3.707				K0.5IIIb
HD129502	14:43:03.62	-05:39:29.5	J2000	1168	B	2000	3.9				F2V
HD139006	15:34:41.26	+26:42:52.8	J2000	249	A	2000	2.214				A1IV
HD135742	15:17:00.41	-09:22:58.4	J2000	359	A	2000	2.605				B8V
HD196867	20:39:38.27	+15:54:43.4	J2000	1081	B	2000	3.8				B9IV
HD186791	19:46:15.58	+10:36:47.6	J2000	73	A	1000	2.724				K3II
HD81937	09:31:31.70	+63:03:42.7	J2000	934	B	2000	3.656				F0IV
HD129989	14:44:59.19	+27:04:27.3	J2000	64	A	1000	2.45				K0II-III
HD175775	18:57:43.79	-21:06:23.9	J2000	200	A	1000	3.53				G9II/III
HD181577	19:21:40.35	-17:50:49.9	J2000	1212	B	2000	3.937				A9IV
HD166937	18:13:45.80	-21:03:31.7	J2000	1125	B	2000	3.841				B2III
HD161096	17:43:28.35	+04:34:02.2	J2000	78	A	1000	2.75				K2III
HD165777	18:07:20.98	+09:33:49.8	J2000	996	B	2000	3.722				A4IVs
HD88284	10:10:35.27	-12:21:14.6	J2000	200	A	1000	3.61				K0III
ALBIREO	19:30:43.28	+27:57:34.8	J2000	102	A	1000	3.085				K3II+...
ADS9913ABC	16:05:26.20	-19:48:10.0	J2000	327	A	2000	2.5				B2
HD106591	12:15:25.56	+57:01:57.4	J2000	689	B	2000	3.32				A3V
HD129246J	14:41:08.95	+13:43:41.8	J2000	1066	B	2000	3.793				A3IVn
HD102647	11:49:03.57	+14:34:19.4	J2000	230	A	2000	2.13				A3Va
HD148387	16:23:59.48	+61:30:51.1	J2000	84	A	1000	2.736				G8IIIb
HD159561	17:34:56.06	+12:33:36.1	J2000	224	A	1000	2.1				A5III
HD187929	19:52:28.36	+01:00:20.3	J2000	286	A	1000	3.88				F6Iab
HD107259	12:19:54.35	-00:40:00.4	J2000	1166	B	2000	3.89				A2IV
HD127762	14:32:04.67	+38:18:29.7	J2000	511	B	2000	3				A7III
HD138917J	15:34:48.14	+10:32:19.9	J2000	1056	B	2000	3.79				F0
HD146051	16:14:20.73	-03:41:39.5	J2000	51	A	1000	2.74				M0.5III
HD198001	20:47:40.55	-09:29:44.7	J2000	1044	B	2000	3.77				A1.5V
HD161797	17:46:27.52	+27:43:14.4	J2000	166	A	1000	3.41				G5IV
HD146791	16:18:19.28	-04:41:33.0	J2000	143	A	1000	3.24				G9.5IIIb
HD140436	15:42:44.56	+26:17:44.2	J2000	1119	B	2000	3.84				B9IV+...
ADS10759	17:41:56.31	+72:08:58.2	J2000	320	A	1000	4				F5
HD153808	17:00:17.37	+30:55:35.0	J2000	1185	B	2000	3.906				A0V
CCDMJ10199+1951AB	10:19:58.35	+19:50:29.3	J2000	42	A	1000	1.98				K0
HD76943	09:00:38.38	+41:46:58.6	J2000	1233	B	2000	3.96				F3V+K0V
HD156014	17:14:38.87	+14:23:25.0	J2000	73	A	1000	3.48				M5Ib-II
BD+144369A	20:37:32.89	+14:35:42.0	J2000	221	A	1000	3.6				F6III
HD187077	19:47:23.35	+18:32:03.5	J2000	1061	B	2000	3.78				B9.5V
HD140573	15:44:16.07	+06:25:32.2	J2000	70	A	1000	2.63				K2IIIb
HD166014	18:07:32.55	+28:45:44.9	J2000	1117	B	2000	3.837				B9.5III
HD80081	09:18:50.63	+36:48:09.3	J2000	1093	B	2000	3.82				A3V

HD180711	19:12:33.30	+67:39:41.5	J2000	124	A	1000	3.082				G9III
HD193496	20:21:00.67	-14:46:52.9	J2000	113	A	1000	3.08				K0II+...
HD93813	10:49:37.48	-16:11:37.1	J2000	116	A	1000	3.11				K0-1III
HD188119	19:48:10.35	+70:16:04.5	J2000	228	A	1000	3.83				G8III
HD95418	11:01:50.47	+56:22:56.7	J2000	282	A	2000	2.346				A1IVps
HD105452	12:08:24.81	-24:43:43.8	J2000	1280	B	2000	4				F1V
HD138918	15:34:48.14	+10:32:20.5	J2000	1066	B	2000	3.8				F0IV
HD177241	19:04:40.98	-21:44:29.3	J2000	212	A	1000	3.771				K0III
HD197989	20:46:12.67	+33:58:12.9	J2000	65	A	1000	2.48				K0III
HD135722	15:15:30.16	+33:18:53.3	J2000	165	A	2000	3.47				G8III
HD96833	11:09:39.80	+44:29:54.5	J2000	102	A	1000	3.005				K1III
HD115659	13:18:55.29	-23:10:17.3	J2000	107	A	1000	3				G8III
HD89758	10:22:19.73	+41:29:58.2	J2000	68	A	1000	3.066				M0III
HD108767	12:29:51.85	-16:30:55.5	J2000	490	B	2000	2.95				A0IV(n)
HD83808	09:41:09.03	+09:53:32.3	J2000	205	A	1000	3.531				F8-G0III+A7m
HD84999	09:50:59.34	+59:02:19.4	J2000	1066	B	2000	3.8				F2IV
HD155763	17:08:47.19	+65:42:52.7	J2000	610	B	2000	3.174				B6III
HD196524	20:37:32.94	+14:35:42.3	J2000	229	A	1000	3.632				F5IV
HD189319	19:58:45.42	+19:29:31.7	J2000	103	A	1000	3.525				M0III
HD188947	19:56:18.37	+35:05:00.3	J2000	235	A	1000	3.88				K0III
HD183912	19:30:43.28	+27:57:34.8	J2000	89	A	1000	3.067				cool
HD192947	20:18:03.25	-12:32:41.4	J2000	200	A	1000	3.585				G8.5III-IV
HD127665	14:31:49.78	+30:22:17.1	J2000	161	A	1000	3.583				K3III
HD198149	20:45:17.36	+61:50:19.6	J2000	152	A	1000	3.41				K0IV
HD163588	17:53:31.72	+56:52:21.5	J2000	200	A	1000	3.741				K2III
HD176437	18:58:56.62	+32:41:22.4	J2000	650	B	2000	3.25				B9III
HD97603	11:14:06.50	+20:31:25.3	J2000	332	A	2000	2.53				A4V
CCDMJ14449+2704AB	14:44:59.21	+27:04:27.2	J2000	293	A	2000	2.39				A0
HD148857	16:30:54.82	+01:59:02.1	J2000	1180	B	2000	3.9				A0V+...
HD83618	09:39:51.36	-01:08:34.1	J2000	225	A	1000	3.909				K2.5III
GJ9615A	18:07:21.98	+09:33:48.0	J2000	1005	B	2000	3.73				A4V
HD187076	19:47:23.35	+18:32:03.5	J2000	126	A	1000	3.82				M2II+...
HD170153	18:21:03.38	+72:43:58.2	J2000	216	A	1000	3.58				F7V
HD153210	16:57:40.09	+09:22:30.1	J2000	118	A	1000	3.2				K2III
HD199629	20:57:10.41	+41:10:01.6	J2000	1221	B	2000	3.939				A1Vne
HD186882	19:44:58.47	+45:07:50.9	J2000	470	A	2000	2.9				B9.5IV+...
HD116656	13:23:55.54	+54:55:31.3	J2000	253	A	2000	2.23				A2V
ADS14279AB	20:46:39.19	+16:07:27.0	J2000	292	A	1000	3.91				F7
HD112300	12:55:36.20	+03:23:50.8	J2000	80	A	1000	3.38				M3III
HD113226	13:02:10.59	+10:57:32.9	J2000	92	A	1000	2.83				G8III
2MASSJ11143546-2112534	11:14:35.46	-21:12:53.5	J2000	7	A	1000	0.1				cool
HD118098	13:34:41.74	-00:35:45.3	J2000	741	B	2000	3.4				A3V
HD110379J	12:41:39.64	-01:26:57.7	J2000	402	A	2000	2.74				F0V+F0V
HD147547	16:21:55.21	+19:09:11.1	J2000	1011	B	2000	3.742				A9III
HD156164	17:15:01.91	+24:50:21.1	J2000	576	B	2000	3.126				A3IV
HD102870	11:50:41.71	+01:45:52.9	J2000	224	A	2000	3.61				F9V
HD98430	11:19:20.44	-14:46:42.7	J2000	200	A	1000	3.56				K0III
HD187076J	19:47:23.25	+18:32:03.4	J2000	126	A	1000	3.82				M2II+...
HD188512	19:55:18.78	+06:24:24.3	J2000	220	A	1000	3.71				G9.5IV