CANADA-FRANCE-HAWAII TELESCOPE

Wade

No code

A homogeneous high-resolution Stokes I+V spectropolarimetric survey of the BRITE-Constellation primary targets

Semester : 2014A

Science Cat. : Stars and stellar population

Abstract

We propose to perform a homogeneous high resolution spectropolarimetric survey of the primary (V<4.0) targets of the BRITE-Constellation mission. We will acquire a single R=65,000, SNR=1000 spectrum of each of the 257 targets previously unobserved with ESPaDOnS. Observations will be acquired in spectropolarimetric mode, providing a high-precision diagnosis of the stellar magnetic field with each spectrum. The data will be used for the determination of physical parameters, rotational velocities, and chemical abundances, along with stellar magnetic characteristics. The unprecedented quality of the dataset may result in serendipitous discoveries, including the detection of faint binary companions.

Telescopes

Telescope	Observing mode	Instruments
CFHT	QSO Regular	ESPaDOnS

Applicants

Name	Affiliation	Email	Country		Potential observer
Gregg Wade	Queen's University / Royal Military College of Canada (Physics)	Gregg.Wade@rmc.ca	Canada	Pi	
A.F.J. Moffat	Université de Montréal	moffat@astro.umontreal.ca	Canada		
W. Weiss	University of Vienna	werner.weiss@univie.ac.at	Austria		
S. Rucinski	University of Toronto	rucinski@astro.utoronto.ca	Canada		
S. Mochnacki	University of Toronto	stefan@lepus.astro.utoronto.ca	Canada		
J. Matthews	University of British Columbia	matthews@astro.ubc.ca	Canada		
Alexandre David-Uraz	Queen's University	adavid-uraz@astro.queensu.ca	Canada		
Bert Pablo	Université de Montréal	hpablo@astro.umontreal.ca	Canada		
Tahina Ramiaramanantsoa	Université de Montréal	tahina@astro.umontreal.ca	Canada		
Gemma Whittaker	University of Toronto	whittaker@astro.utoronto.ca	Canada		
Aleksander Schwarzenberg-Czerny	Copernicus Astronomical Center	alex@camk.edu.pl	Poland		
Rainer Kuschnig	University of Vienna	rainer.kuschnig@univie.ac.at	Austria		
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Zipcode	K7K 7B4
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State	Ontario
Country	Canada

Applicants are continued on the last page

Requested Time (exposure + overheads) in hours (in nights for Classical)

11.0

Overall scheduling requirements

None

Observing runs

Run	Instrument	Seeing	Config	Details
A	ESPaDOnS	1.00 - 1.50" (ESPaDOnS)	Observing mode: Polarimetry Read-out mode : Normal	None

Targets

Field	RA	Dec	Epoch		Runs	Moon	Seeing Lower	Seeing Upper	S/N	Magnitude	Diameter	Comments

Scientific Justification

Context

BRITE-Constellation (where BRITE stands for BRIght Target Explorer) is an international nanosatellite mission to monitor photometrically, in two colours, brightness and temperature variations primarily of stars brighter than V ≈ 4, with precision and time coverage not possible from the ground. The mission design consists of three pairs of 7 kg nanosats (hence "Constellation") from Austria, Canada and Poland carrying 3 cm aperture optical telescopes and CCDs. One instrument in each pair is equipped with a blue filter; the other, a red one. The prime contractor for the BRITE mission is the University of Toronto Institute for Aerospace Studies Space Flight Laboratory (UTIAS-SFL). **The first pair of BRITE nanosats (funded by Austria) was launched successfully from India on 25 February 2013, into a low-Earth dusk-dawn polar orbit.**

Each BRITE instrument has a wide field of view (≈ 24 degrees), so up to 15 bright stars can be observed simultaneously in 32 x 32 sub-rasters. Photometry of additional fainter targets (with reduced precision but thorough time sampling) will be possible through on-board data processing. A critical technical element of the BRITE mission is the three-axis attitude control system to stabilize a nanosat with very low inertia. The pointing stability is better than 1.5 arcminute rms, a significant advance - by almost 2 orders of magnitude - over any previous nanosatellite.

BRITE-Constellation will primarily measure p- and g-mode pulsations to probe the interiors and ages of stars through asteroseismology. The BRITE sample of many of the brightest stars in the night sky is dominated by the most intrinsically luminous stars, comprising two basic classes: **Hot luminous H-burning stars** (O to F stars), for which analyses of their variability have the potential to help solve two outstanding problems: the sizes of convective cores in massive stars and the influence of rapid rotation on their structure and evolution; and **cool luminous stars** (AGB stars, cool giants and cool supergiants), for which measurements of the time scales involved in surface granulation and differential rotation will constrain turbulent convection models.

Mass loss from these stars (especially the massive supernova progenitors) is a major contributor to the evolution of the interstellar medium, so in a sense this sample dominates cosmic "ecology" in terms of future generations of star formation. Moreover, the massive stars are believed to share many characteristics of the lower mass range of the first generation of stars ever formed (although the original examples are of course long gone).

The Canadian pair of BRITE nanosats are under construction at UTIAS-SFL, and are planned for launch during 2014.

This proposal

This proposal requests a modest time allocation to obtain homogeneous high-quality reference spectra and accompanying magnetic field measurements (at no extra cost) for **all** BRITE-Constellation primary (V<4) targets previously unobserved using ESPaDOnS. Of the 354 V<4 BRITE targets north of -45 deg, 257 have never been previously observed with ESPaDOnS (according to an exhaustive search of the CFHT Archive performed by CADC astronomer JJ Kavelaars). For each of these stars we will acquire a single high resolution spectrum with superb (1000) signal-to-noise ratio. These reference spectra - of unprecedented quality for most stars in

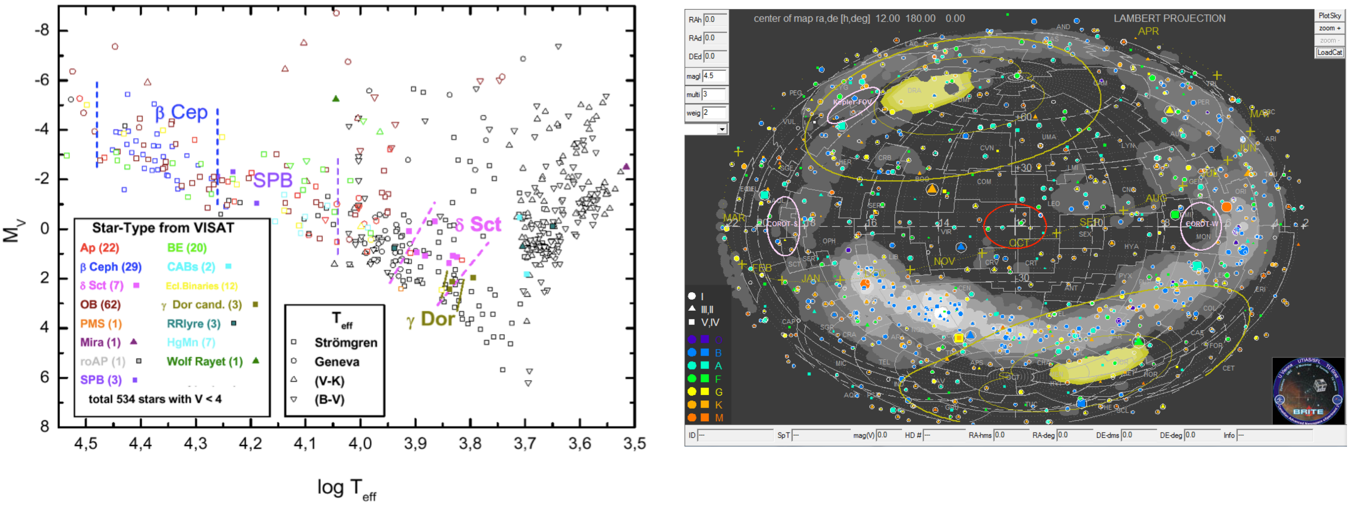

Fig. 1: Left: HR diagram of the brightest BRITE-Constellation targets. Right: Distribution of these targets on the sky, with encoding of spectral type and luminosity class. The BRITE targets span the entire HR diagram of massive and evolved stars, and are distribution relatively uniformly across the entire sky.

our sample - will be employed to constrain stellar physical parameters, rotational velocities, and photospheric chemical abundances and atmospheric turbulence. In early B and O stars, Balmer lines will provide wind diagnostics for determination of mass-loss rates. In late-type stars, other strong lines such as Ca II H&K will provide indirect diagnostics of stellar activity. The very high SNR of these spectra will also potentially allow the detection of line profile distortions due to pulsations and surface structures (photospheric spots), as well as previously undetected faint spectroscopic companions.

Each observations will also yield a high-precision diagnosis of the Stokes V spectrum, which when analysed using Least-Squares Deconvolution (LSD) provides the most sensitive diagnosis of the presence and properties of stellar magnetic fields. For stars with spectral types earlier than about F0 (approximately one-half of the sample), we expect to detect organised fossil magnetic fields with longitudinal components of tens to hundreds of gauss in somewhat less than 10% of these objects (with the remainder expected to lack any detectable magnetic field; see e.g. Wade et al. 2012). For stars with spectral types later than F0, we expect much weaker longitudinal fields of a few tenths to a few tens of G due to envelope dynamos (see e.g. Aurière et al. 2012, Petit et al. 2013, Grunhut & Wade 2010). This survey is not meant to provide a detailed characterisation of the magnetic fields of individual targets, but will serve to identify many of those that host dynamically-significant magnetic fields, and that may be candidates for further observations in the future.

The spectral and magnetic information to be derived from this data set will prove to be indispensable when integrated with the BRITE light curves, in particular given the importance of magnetic fields in determining the photometric behaviour of this large and complete sample of stars.

Technical Justification

The aim of this project is to acquire homogeneous, high-quality ESPaDOnS Stokes V spectra of the 354 V<4 BRITE targets north of -45 deg. According to the CFHT archive, 97 of these targets have been previously observed with ESPaDOnS. We propose to obtain Stokes I+V spectra for the remaining 257 stars.

Our primary aims are to acquire state-of-the-art reference spectra for each star, as well as a high-precision diagnosis of their magnetic fields. Our quality target is a resolving power of 65,000, full spectral coverage from 360-1000 nm, and a peak signal-to-noise ratio per 1.8 km/s pixel of over 1,000. Since all of our targets are bright, the time request is dominated by pointing and readout overheads.

Due to the large number of targets, we have summarised their observational properties and computed sub-exposure and total I-times in a PDF file that can be accessed at the following link:

https://dl.dropboxusercontent.com/u/7869678/BRITE_CFHT_14A.pdf

We have computed exposure times based on the ESPaDOnS/Olapa ETC. For a V=4.0 star with Teff=10,000 K, with 1” seeing and airmass of 1.3, a SNR of 1000 per 1.8 km/s pixel in the polarised spectrum is achieved with a subexposure time of 60s. All exposure times have been extrapolated using this standard, and overheads computed assuming fast readout.

Following acquisition, reduction, careful merging and normalisation, the magnetic field measurements and the spectral database (to be reported in a dedicated publication) will be made available publicly.

Magnetic diagnosis will be performed using Least Squares Deconvolution (e.g. Donati et al. 1997, Kochukhov et al. 2010) using tuned line masks. This procedure has been demonstrated to be the most sensitive approach to detecting and modeling stellar magnetic fields. Although the precision of the magnetic diagnosis will depend sensitively on stellar spectral properties, one can project that a typical mid A-type star with vsini=75 km/s observed with SNR=1000 will yield a longitudinal field error bar of 10-15 G. A typical early K giant, on the other hand, would yield an error bar of just 0.3 G.

This project is superbly suited to filling RA gaps in the CFHT queue, consisting of many short (<400s) OGs with targets distributed more-or-less uniformly on the sky.

Although the total time required for this program is only 22 hours, we are requesting the time over 2 semesters, both in order to reduce the impact on PI time, and in order to reduce the rate of data acquisition.

RA (h): 0-4	4-8	8-12	12-16	16-20	20-24
3.7	4.2	2.6	3.8	4.8	2.8

Table 1: Table of requested time distribution (in hours) as a function of RA. Note that this distribution includes all targets to be observed over 2 semesters, twice the time requested in the current proposal.

Students involved

Student	Level	Applicant	Supervisor	Applicant	Expected completion date	Data required
Tahina Ramiaramanantsoa	Doctor	Yes	A.F.J. Moffat	Yes	2016/09	Yes
Alexandre David-Uraz	Doctor	Yes	Gregg Wade	Yes	2015/09	Yes

Linked proposal submitted to this TAC: No

Linked proposal submitted to other TACs: No

Any other expenditure

Relevant previous Allocations: No

Related Publications

Search for a Magnetic Field via Circular Polarization in the Wolf-Rayet Star EZ CMa, de la Chevrotière et al. (with Moffat), 2013
The Magnetic Properties of Galactic OB Stars from the Magnetism in Massive Stars Project, Wade et al., 2013
A magnetic confinement versus rotation classification of massive-star magnetospheres, Petit et al. 2013
Discovery of a magnetic field in the rapidly rotating O-type secondary of the colliding-wind binary HD 47129 (Plaskett's star), Grunhut et al. 2013
Moffat et al. 2013, Precision photometry and variability of massive stars from space
Investigating the spectroscopic, magnetic and circumstellar variability of the O9 subgiant star HD 57682, Grunhut et al. 2012
NGC 1624-2: a slowly rotating, X-ray luminous Of?cp star with an extraordinarily strong magnetic field, Wade et al. 2012
David-Uraz et al. 2012, Using MOST to reveal the secrets of the mischievous Wolf-Rayet binary CV Ser
Systematic detection of magnetic fields in massive, late-type supergiants, Grunhut et al., 2010
Discovery of a weak magnetic field in the photosphere of the single giant Pollux, Aurière et al. (with Wade), 2009

Observing run info :