14246 - The Fastest Rotating Stars

Cycle: 23, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) VFTS-102	COS/FUV COS/NUV	3	12-Nov-2015 21:02:40.0	yes
02	(2) VFTS-285	COS/FUV COS/NUV	1	12-Nov-2015 21:02:43.0	yes

4 Total Orbits Used

ABSTRACT

The VLT FLAMES Survey of the massive stars in the Tarantula Nebula region
of the LMC has led to the discovery of the two fastest rotating stars:
VFTS 102 and 285 with V sin i = 610 and 609 km/sec. These two O-dwarfs
may be single stars born with extraordinarily high angular momentum or
they may have been spun up in a binary system by mass transfer or merger.
Extreme rotators like these suffer gravity darkening that makes their

equatorial regions cooler than the polar zones, so that the equatorial parts close to the limb contribute less flux and create narrower lines. We show how HST/COS spectroscopy of the far-ultraviolet spectra can be used with the optical rotational line broadening to estimate this gravity darkening effect and to determine the ratios of equatorial to critical rotation velocity for these two stars. This ratio is key to describing the bipolar winds of rapidly rotating stars, and the COS spectra will record the important wind lines in the FUV for comparison with models of asymmetric winds. The COS spectra will yield estimates of the stellar masses, radii, rotation rates, and abundances that will help us assess the origin and destiny of these remarkable stars in particular and massive rotating stars in general.

OBSERVING DESCRIPTION

We propose to obtain COS observations of the FUV spectrum of VFTS 102 and 285 using the G130M grating to cover most of the range from 1150 to 1450 with a resolving power of 18,000 (although we may make a modest reduction in resolving power by spectral smoothing in the data analysis stage to increase the signal-to-noise ratio). Our primary goal is to obtain cross-correlation functions of the FUV photospheric lines with model spectra. Numerical tests with model spectra indicate that we can estimate the FWHM of the cross-correlation function to better than 5% accuracy (comparable to the optical measurements of V sin i; Ramirez-Agudelo et al. 2013) with a signal-to-noise ratio of S/N = 10 per resolution element, so our goal is to obtain a S/N = 10 at 1310 in a single visit to each target. This S/N is also adequate for our investigation of the line morphology of the wind lines of Si III 1206, N V 1240, and Si IV 1400.

We used the COS ETC and assumed that the spectral energy distributions are given by reddened versions of Castelli & Kurucz model spectra for the spectral classifications

of the two targets. The model spectra were normalized using the UIT B1 magnitudes (effective wavelength = 1521 Angstroms) of the targets from Parker et al. (1998, AJ, 116, 180) and B-V colors from Evans et al. (2011), and the extinctions were estimated using intrinsic colors from Wegner (1994) and a ratio of total-to-selective extinction of R = 3.41 (LMC average). The COS ETC gave exposure times of 4500 and 440 seconds for VFTS 102 and 285, respectively (the latter being hotter and less reddened). Following the example in the Instrument Handbook, we would obtain this result through several exposures at each of four FP-POS spectral offsets and two or three CENWAVE positions in order to fill in the gap in spectral coverage between the two COS detectors. All these exposures would be made in standard TIME-TAG mode.

We estimate that there are 54 minutes of visibility per orbit for the declination of both targets (delta = -69 deg). In the first orbit, we require 3 minutes for acquisition, 5 minutes for COS FUV acquisition and search, 2 minutes for PEAKXD cross dispersion peakup, and 5 minutes for PEAKD peakup in the dispersion direction. This leaves 39 minutes for science exposures. In succeeding orbits, we need 4 minutes for re-acquisition, yielding a net of 50 minutes for science exposure. Thus, for the fainter target, VFTS 102, we are requesting three orbits (with 4, 4, and 4 sub-exposures for each of 3 CENWAVE positions; this will require orbits 1, 2, and 3, respectively). We can obtain all the sub-exposures (four in each of 2 CENWAVE positions) in a single orbit for the brighter target, VFTS 285.

Dr. Hugues Sana kindly provided F275W AB magnitudes for both stars based upon unpublished HST observations:
m(F275W) = 15.044 for VFTS-102
m(F275W) = 14.013 for VFTS-285
The COS ETC calculations using these estimates led to exposure times that are a factor of 3.1 and 3.9 times lower for VFTS-102 and VFTS-285, repectively, than given above. Given this uncertainty, the BUFFER-TIME estimates were lowered by these factors (and the recommended 2/3) from the ETC calculations in order to be sure the

buffers do not reach full capicity.

Visit

Proposal 14246, VFTS-102 (01), implementation Fri Nov 13 02:02:44 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Comments: 3 orbit visit

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	VFTS-102 Alt Name1: UCAC4-105-014018 Alt Name2: 2MASS-J05373924-6909510	RA: 05 37 39.2400 (84.4135000d) Dec: -69 09 51.12 (-69.16420d) Equinox: J2000	Proper Motion RA: -0.1 mas/yr Proper Motion Dec: -1.3 mas/yr Parallax: 0." Epoch of Position: 2000.0	V=15.70+/-0.10 E(B-V)=0.63+/-0.10	Reference Frame: ICRS

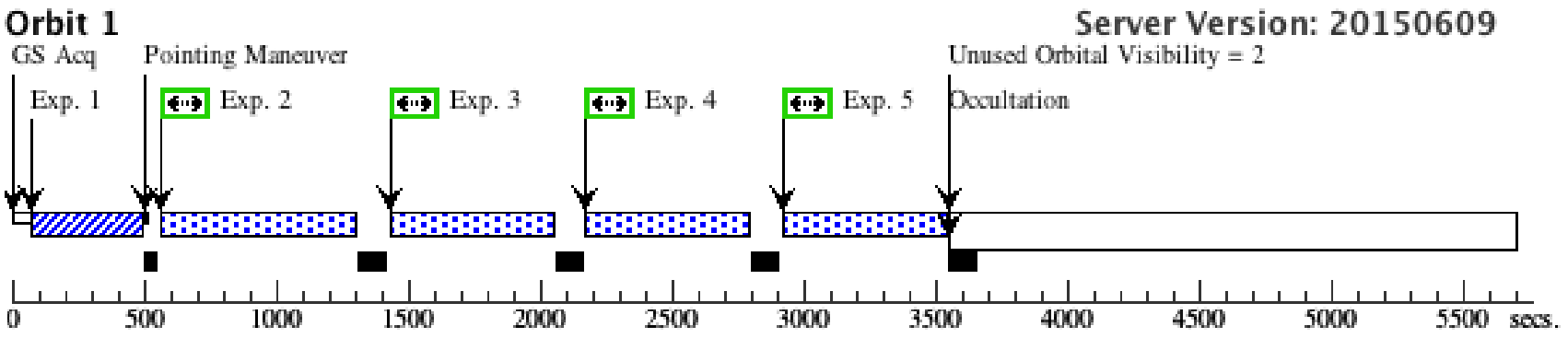
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
UIT m(B1)=14.55
F(1521)=5.5E-15 erg/s/cm^2/Angstrom
Extended=NO

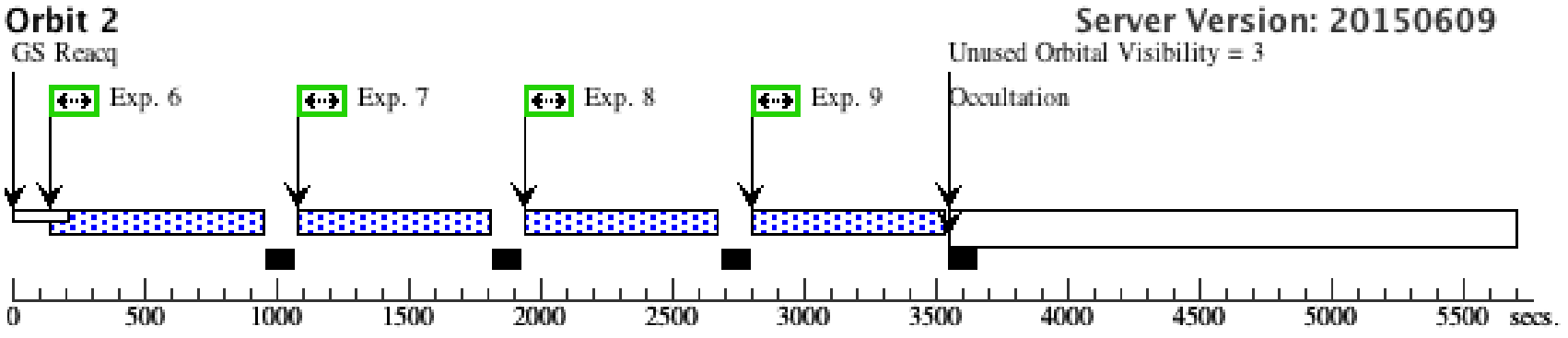
Exposures

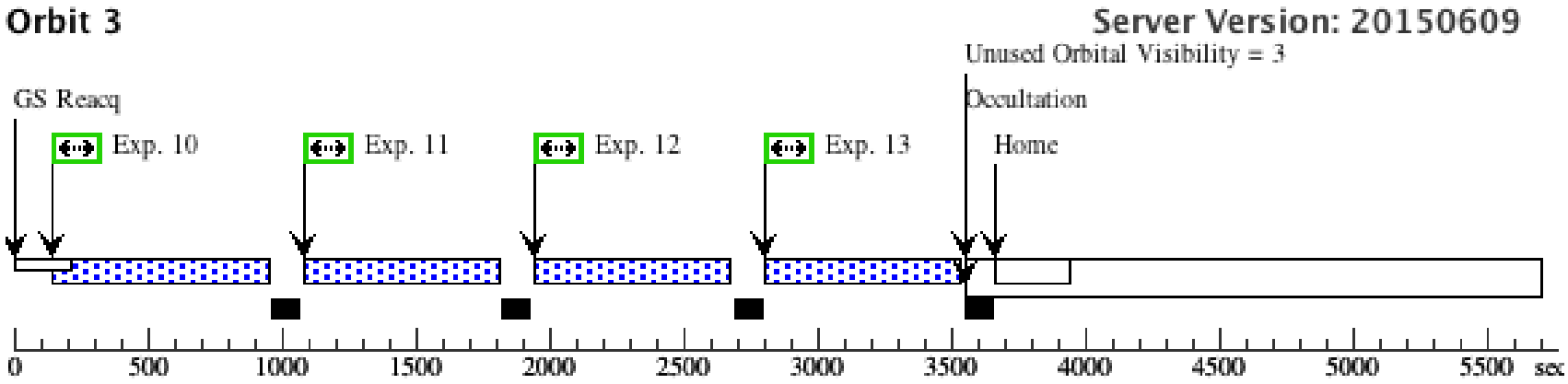
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquistion (COS.ta.752537)	(1) VFTS-102	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				51.0 Secs (51 Secs) *[==>]*	***[1]***
Comments: COS NUV image acquisition sequence.									
2	Science exposure 1309 FP1 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1309 A	FP-POS=1; BUFFER-TIME=565			565 Secs (565 Secs) *[==>]*	***[1]***
3	Science exposure 1309 FP2 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1309 A	FP-POS=2; BUFFER-TIME=565			565 Secs (565 Secs) *[==>]*	***[1]***
4	Science exposure 1309 FP3 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1309 A	FP-POS=3; BUFFER-TIME=565			565 Secs (565 Secs) *[==>]*	***[1]***
5	Science exposure 1309 FP4 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1309 A	FP-POS=4; BUFFER-TIME=565			565 Secs (565 Secs) *[==>]*	***[1]***
6	Science exposure 1300 FP1 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=1; BUFFER-TIME=681			681 Secs (681 Secs) *[==>]*	***[2]***
7	Science exposure 1300 FP2 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=2; BUFFER-TIME=681			681 Secs (681 Secs) *[==>]*	***[2]***
8	Science exposure 1300 FP3 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=3; BUFFER-TIME=681			681 Secs (681 Secs) *[==>]*	***[2]***
9	Science exposure 1300 FP4 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=4; BUFFER-TIME=681			681 Secs (681 Secs) *[==>]*	***[2]***
10	Science exposure 1318 FP1 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=1; BUFFER-TIME=681			681 Secs (681 Secs) *[==>]*	***[3]***
11	Science exposure 1318 FP2 (COS.sp.720399)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=2; BUFFER-TIME=681			681 Secs (681 Secs) *[==>]*	***[3]***

	12	Science exposure 1318 FP3 (COS.sp.72099)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=3; BUFFER-TIME=681	681 Secs (681 Secs) *[==>]*	***[3]***
	13	Science exposure 1318 FP4 (COS.sp.72099)	(1) VFTS-102	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=4; BUFFER-TIME=681	681 Secs (681 Secs) *[==>]*	***[3]***

Orbit Structure







Visit

Proposal 14246, VFTS-285 (02), implementation Fri Nov 13 02:02:45 GMT 2015

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Comments: 1 orbit visit

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	VFTS-285 Alt Name1: 2MASS-J05381736-6905425 Alt Name2: UCAC4-105-014155	RA: 05 38 17.3400 (84.5722500d) Dec: -69 05 42.14 (-69.09504d) Equinox: J2000	Proper Motion RA: -0.40 mas/yr Proper Motion Dec: -0.23 mas/yr Parallax: 0" Epoch of Position: 2000.0	V=15.63+/-0.10 E(B-V)=0.23+/-0.10	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
UIT m(B1)=12.66
F(1521)=3.1E-14 erg/s/cm^2/Angstrom
Note that target VFTS-285 has a close companion VFTS-290 that is similar in brightness at a separation of 4 arcsec.
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Acquistion (COS.ta.752538)	(2) VFTS-285	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				11.0 Secs (11 Secs) *[==>]*	***[1]***
Comments: COS NUV image acquisition sequence.									
2	Science exposure 1300 FP1 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=1; BUFFER-TIME=195			195 Secs (195 Secs) *[==>]*	***[1]***
3	Science exposure 1300 FP2 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=2; BUFFER-TIME=195			195 Secs (195 Secs) *[==>]*	***[1]***
4	Science exposure 1300 FP3 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=3; BUFFER-TIME=195			195 Secs (195 Secs) *[==>]*	***[1]***
5	Science exposure 1300 FP4 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1300 A	FP-POS=4; BUFFER-TIME=195			195 Secs (195 Secs) *[==>]*	***[1]***
6	Science exposure 1318 FP1 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=1; BUFFER-TIME=191			191 Secs (191 Secs) *[==>]*	***[1]***
7	Science exposure 1318 FP2 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=2; BUFFER-TIME=191			191 Secs (191 Secs) *[==>]*	***[1]***
8	Science exposure 1318 FP3 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=3; BUFFER-TIME=191			191 Secs (191 Secs) *[==>]*	***[1]***
9	Science exposure 1318 FP4 (COS.sp.720372)	(2) VFTS-285	COS/FUV, TIME-TAG, PSA	G130M 1318 A	FP-POS=4; BUFFER-TIME=191			191 Secs (191 Secs) *[==>]*	***[1]***

Orbit Structure