15512 - Weaving the history of the solar wind with magnetic field lines

Cycle: 26, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

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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) IOT-HOR	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	07-Jan-2019 11:00:18.0	yes

3 Total Orbits Used

ABSTRACT

Despite its fundamental role for the evolution of the solar system, our observational knowledge of the wind properties of the young Sun comes from a single stellar observation. This unexpected fact for a field such as astrophysics arises from the difficulty of detecting Sun-like stellar winds. Their detection relies on the appearance of an astrospheric signature (from the stellar wind-ISM interaction region), visible only with the aid of high-resolution HST Lyman-alpha spectra. However, observations and modelling of the present day Sun have revealed that magnetic fields constitute the main driver of the solar wind, providing guidance on how such winds would look like back in time. In this context we propose observations of four young Sun-like stars in order to detect their astrospheres and characterise their stellar winds. For all these objects we have recovered surface magnetic field maps using the technique of Zeeman Doppler Imaging, and developed detailed wind models based on these observed field distributions. Even a single detection would represent a major step forward for our understanding of the history of the solar wind, and the outflows in more active stars. Mass loss rate estimates from HST will be confronted with predictions from realistic models of the corona/stellar wind. In one of our objects the comparison would allow us to quantify the wind variability induced by the magnetic cycle of a star, other than the Sun, for the first time. Three of our targets are planet hosts, thus the HST spectra would also provide key information on the high-energy environment of these systems, guaranteeing their legacy value for the growing field of exoplanet characterisation.

OBSERVING DESCRIPTION

Primary Objective: Our primary goal is to measure stellar mass loss rates by accurately modelling the observed astrospheric Hi absorption in the Lyman-alpha line of four young Sun-like stars (iota Horologii, HD1237, HD147513, HD190771; S. Types: G0V to G8V; Ages: 400 to 880 Myr). This proposal gives continuity to the program started during Cycle 25 (GO-15299), with a second observation (3 orbits) of iota Horologii aimed at determining if the mass loss rate due to the stellar wind varies as a function of the magnetic cycle taking place in the star.

Generalities:

The measurement of solar-type winds is only possible with the unique capabilities of HST/STIS. The sole transition in which the astrospheric boundary is detectable is Lyman-alpha at 1215.6 Angstroms. Also the interstellar column density must be moderately low (i.e., log N(H I) < 18.4), in order that the saturated ISM H I absorption does not overlap with the astrospheric signal. Practically all resonance lines strong enough to be sensitive to such low ISM column densities are in the UV.

The high spectral resolution capabilities of STIS are critical for the measurement of astrospheric structure. This requires the determination of ISM cloud properties (e.g., velocity, temperature), so an accurate absorption line profile can be determined (Redfield & Linsky 2008). Only STIS has the high spectral resolution capability to resolve closely spaced ISM absorption profiles (such as for Mg II in E230H; R ~ 110000) or astrospheric absorption from interstellar absorption (as well as D I from H I in E140M; R ~ 45800).

Observing Strategy:
We propose to use the high resolution E230H grating to observe Mg II and Fe II. These "heavy" ions are not significantly broadened thermally, and provide sharp line profiles to resolve the velocity structure of the ISM along the line of sight. Because the hydrogen at the astrospheric interface is hot (T ~ 100000 K), it has a broad absorption profile, and does not necessarily require high spectral resolution. Therefore, to maximize S/N, we plan to use the E140M setting. Due to the wide spectral range of STIS, we would obtain practically the entire far-UV band (from 1150-1700 Angstroms) and several more ISM absorption lines (e.g., D I, C II, N I, O I, Si II, Si III, Al II) in addition to Lyman-alpha. With the defined velocity structure by Fe II and Mg II, we could also use all of these lines (Redfield & Linsky 2004).

After acquisition, peakup, and observational overheads are considered, we expect at least 28 minutes to be available in the first orbit for the E230H exposure. This provides time to attain very high S/N > 50 at the half-maximum (that is, one half FWHM from the line center, because it is unlikely that the ISM absorption will be centered at the same velocity as the star) of the strong Mg II lines. These S/N levels allow for the detection of weak column densities (log N(Mg II) ~ 11.0), even in blended profiles (demonstrated in Redfield & Linsky 2002). After acquisition and overheads are considered, we expect at least 41 minutes of exposure time to be available in the second orbit for the E140M exposure, and 48 minutes in subsequent orbits. To obtain a S/N > 30, which is required to model the Ly-alpha profile (see Wood+2005a), 3 orbits are required.

Timing Constraints:
The narrow apertures available with STIS are likewise required to minimize the contamination of the geocoronal emission line in Lyman-alpha, and allow for an accurate astrospheric measurement. We require a minimal timing constraint to ensure that the geocoronal line is well within the saturated core of the broad ISM Lyman-alpha absorption. This has been taken into account in the visit planner for each target.

Brightness limits:
All of our stars have UV spectra characterized by minimal continua, but strong emission lines. For this reason, they fall far short of the global brightness limit. The emission lines also fall far short of the local brightness limit. The two emission lines of interest in this proposal (Lyman-alpha and Mg II) are also the brightest, and therefore, the procedure for estimating the S/N near their peaks is also used to test for brightness limit

violations. For the E230H, the local count rate is 20x lower than the limit and 10x lower than the global count rate limit. There is a reduced contribution from the continuum in the E140M setting so the observations are well below the local and global limits.

Proposal 15512 - Visit 01 - Weaving the history of the solar wind with magnetic field lines

Visit

Proposal 15512, Visit 01, implementation — Mon Jan 07 16:00:19 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/NUV-MAMA, STIS/CCD, STIS/FUV-MAMA

Special Requirements: BETWEEN 01-AUG-2019:00:00:00 AND 18-SEP-2019:00:00:00

Fixed Targets

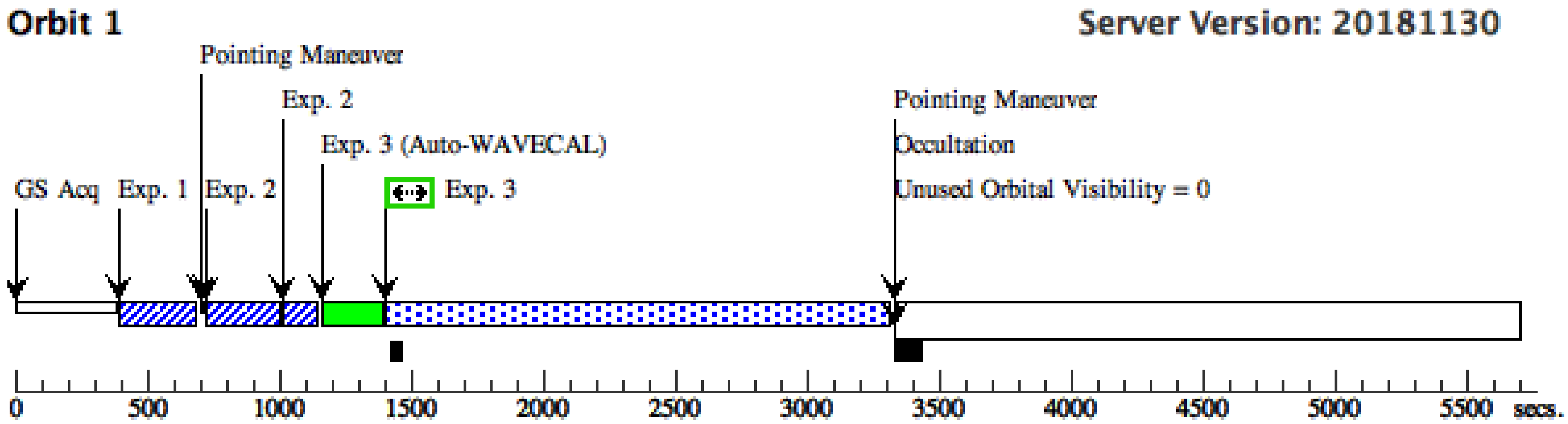
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	IOT-HOR Alt Name1: HIP12653 Alt Name2: GSC2S0321012248	RA: 02 42 33.1600 (40.6381667d) Dec: -50 48 3.00 (-50.80083d) Equinox: J2000	Proper Motion RA: +333.73 mas/yr Proper Motion Dec: +219.21 mas/yr Parallax: 0.0580" Epoch of Position: 1991.25 Radial Velocity: 16.943 km/sec	V=5.40+/-0.02 TYPE=G0V, B-V=0.561, E(B-V)=0, F-LINE(2796)=4.02E-12, W-LINE(2796)=0.6, F-LINE(1216)=2.86E-12, W-LINE(1216)=0.7	Reference Frame: ICRS

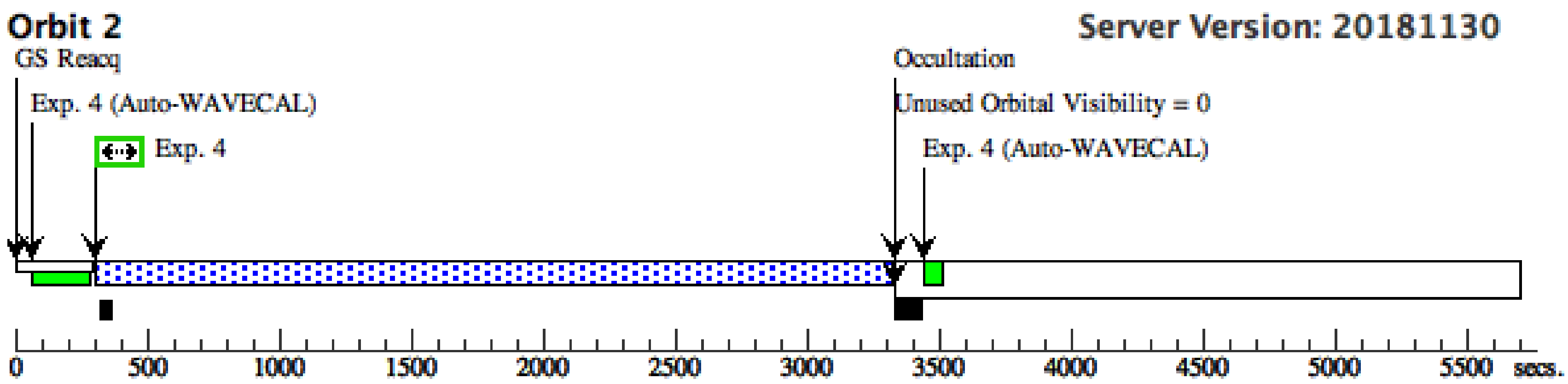
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANETARY SYSTEM, G V-IV]

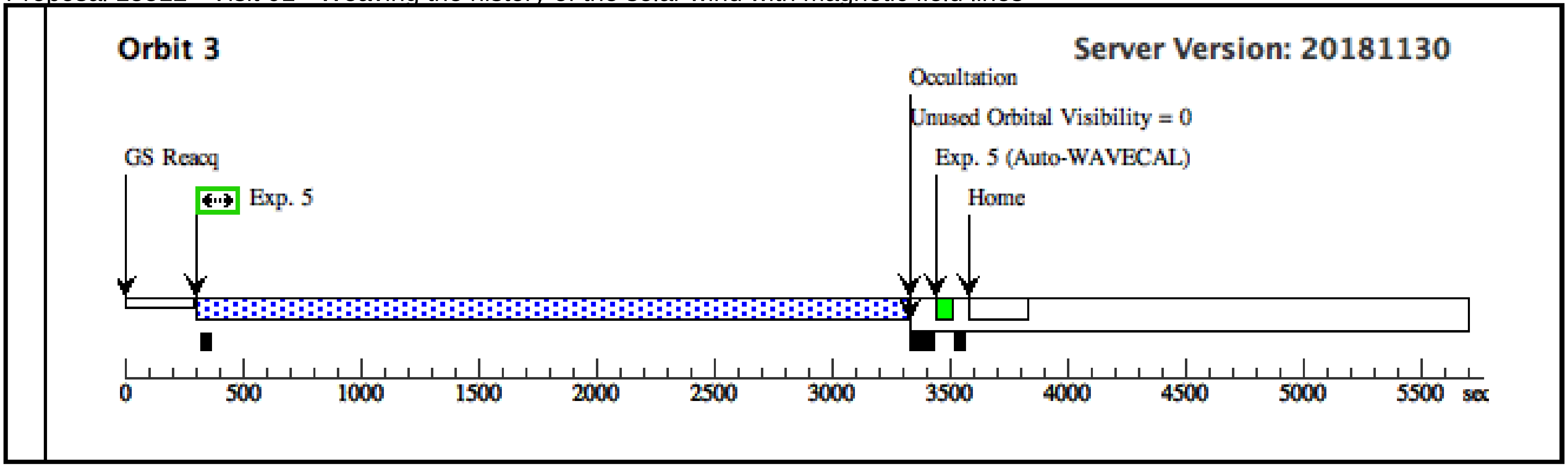
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) IOT-HOR	STIS/CCD, ACQ, F25ND3	MIRROR		GS ACQ SCENARIO BASE1BE		0.40 Secs (0.4 Secs) *[==>]*	***[1]***
Comments: Minimum exposure time for the detector.									
2		(1) IOT-HOR	STIS/CCD, ACQ/PEAK, 0.2X0.09	G430M 4451 A				0.20 Secs (0.2 Secs) *[==>]*	***[1]***
Comments: Minimum exposure time for the detector.									
3	(STIS.sp.10 11399)	(1) IOT-HOR	STIS/NUV-MAMA, ACCUM, 0.2X0.09	E230H 2713 A				1400 Secs (1899 Secs) *[==>1899.0 Secs]*	***[1]***
Comments: Requested Signal/Noise Ratio = 50.000 at wavelength 2796.00 Angstrom (per resolution element) gives: Time = 1,362.0345 seconds									
4	(STIS.sp.10 11404)	(1) IOT-HOR	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				3000 Secs (3001 Secs) *[==>3001.0 Secs]*	***[2]***
Comments: Requested Signal/Noise Ratio = 30.000 at wavelength 1216.00 Angstrom (per resolution element) gives: Time = 5,807.5956 seconds									
5	(STIS.sp.10 11404)	(1) IOT-HOR	STIS/FUV-MAMA, ACCUM, 0.2X0.2	E140M 1425 A				3000 Secs (3001 Secs) *[==>3001.0 Secs]*	***[3]***
Comments: Requested Signal/Noise Ratio = 30.000 at wavelength 1216.00 Angstrom (per resolution element) gives: Time = 5,807.5956 seconds									

Orbit Structure






Orbit 3
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Occultation
Unused Orbital Visibility = 0
GS Reacq
Exp. 5 (Auto-WAVECAL)
Exp. 5
Home
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5500
sec