15203 - First exploration of a single thermal interface between the two dominant phases of the interstellar medium

Cycle: 25, 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) HD32309 WAVE	STIS/CCD STIS/FUV-MAMA	4	26-Jul-2017 19:02:20.0	yes

4 Total Orbits Used

ABSTRACT

Two phases of the interstellar medium, the Warm Neutral Medium (WNM) and the Hot Ionized Medium (HIM) occupy most the volume of space in the plane of our Galaxy. Because the boundaries between these phases are important sources of energy loss for the hot gas, they are supposed to play an important role in the thermal structure and evolution of the ISM and of galaxies.

Many theorists have created descriptions of the nature of such boundaries and have derived two fundamental concepts: (1) a conductive interface and (2) a turbulent mixing layer.

We have yet to observe in detail either kind of boundary. This is achieved by using UV absorption lines of moderately high ionization stages of heavy elements. Yet, over most lines of sight the diagnostics are blurred out by the superposition of different regions with vastly different physical

conditions, making them difficult to interpret. To characterize the nature of the physical processes at a boundary one must observe along a sight line that penetrates just one such region. The simplest configuration is the outer boundary of the Local Cloud, the WNM ((T ~ 7000 K) that surrounds the Sun and which is embedded in a very low density, soft X-ray emitting hot medium (~ 10^6 K) that fills a cavity (~ 200 pc in diameter) called the Local Bubble.

We propose to observe an ideal target: a nearby, bright B9V star (i.e. hot enough to provide a high-SNR continuum, but not enough to contaminate it with absorptions from circumstellar high-ionization species), located in a direction where the relative orientation of the magnetic field and the cloud boundary does not quench thermal conduction and thus favors a full extent of the interface.

OBSERVING DESCRIPTION

Instrument/grating choice -

We plan to observe HD 32309 with STIS, using the echelle grating E140H. The choice of E140H is guided by the need for very high resolution:

1) The resolution must be sufficient to kinematically resolve the absorptions from eventual different interstellar components in the line of sight, typically separated by a few km/s.

2) Accurate measurements of velocity offsets are important, since they represent an important clue to determine which process is at work in the interface region or since they might reveal the age of a conduction interface.

3) We need to measure line widths accurately enough to sense the thermal Doppler broadenings and the differential velocities inside the evaporation (or condensation) flows.

Wavelength settings -

We originally planned to use E140H in two settings. One centered on 1489A gives simultaneous access to the C IV (1548, 1550A) and Si IV (1393, 1402A) doublets.

The second setting centered on 1271 A gives access to the N V doublet (1238, 1242 A), as well as to the Si III line at 1206A and a wealth of lines from less ionized elements: H I, O I, N I, S II, Si II, C II and C II*. We plan to use the low ionization species to identify the velocity, ionization state, and other physical conditions in the foreground WNM (our cloud surrounding the Sun). Obtaining a velocity reference from the WNM is important for sensing the kinematics of the gas within the interface.

Exposure times and orbit numbers -

We need a signal-to-noise ratio (S/N) of 100 to securely detect C IV features with N(C IV) = several 10^11 cm-2 which correspond to the model

predictions in conduction fronts with only moderate magnetic suppression (Borkowski et al, 1990). Predictions for high ions in turbulent mixing layers are higher and thus they would be more easily detected. Thermal broadening at 10^5 K spreads the absorption over 20 km/s (0.1 A or 7.5 resolution elements); therefore such a column density produces an absorption depth of a few %. A S/N of 100 on both the C IV and Si IV lines on the E140H setting at 1489 A is reached in 30 min.
Our goal of obtaining a S/N of 100 on the N V doublet makes our exposure time requirement for the 1271A central wavelength setting to be 120 minutes. In that time many other lines of interest (like O I, S II, Si II, C II and C II*) should benefit from a S/N well in excess of 100 considering their continuum levels.
For this long exposure, any single-orbit sub-exposure exceeding ~2000 s is broken into two subexposures, to mitigate thermal drifts.

Need for dithering/FP-SPLIT -
Our experience with previous STIS spectra of other stars like alpha Leo (Gry & Jenkins, 2017) has revealed that the main uncertainty associated with the detection of weak, broad features that are expected for highly ionized species, is created by a low frequency, fixed-pattern noise arising from sensitivity variations in the STIS image sensor. In high S/N spectra these perturbations overshadow photon counting noise because they create random disturbances in the apparent fluxes that could obliterate (or masquerade as) real absorption features.
We therefore considered performing the dithering possibility offered by FP-SPLITs to overcome flat-field variations in the MAMA detector response. The set of FP-SPLIT slits 0.2X0.06FP(A-E), consisting of five 0.2" X 0.06" apertures spaced to place the spectrogram at different detector locations, has a throughput only 10% lower than the usual 0.2X0.09 aperture, and is well fit for our observations.
However, we have been informed that "the focus causes irregular throughput drops on the small echelle slits, so using the smaller slit width with the FP-SPLIT option may increase the likelihood and/or the magnitude of a throughput drop". We were thus advised to use a different dither option which is to make the observations in different adjacent cenwaves so that the spectral lines of interest fall on very different places on the detector. This is the strategy we have adopted here.

MAMA bright limits -
Our star HD32209 has been observed with IUE in the Large Aperture, under spectrum SWP40454. We have thus measured the fluxes on this spectrum at different wavelengths, and we have also uploaded the complete IUE spectrum hd32309-iue.txt. To make sure that our target does not violate the MAMA
bright limit we have used the STIS spectroscopic ETC with two different spectrum estimates: the complete uploaded IUE spectrum and the Bruzual Synthetic Stellar Spectra for a B9 V, normalized to the measured fluxes.
For the 1489A setting, the uploaded IUE spectrum gives a total count rate of 189 058 cts/s (STIS.sp.1008616), whereas the Synthetic spectrum

normalized to the measured flux of 1.13e-10 gives 175 081 cts/s (STIS.sp.1008666).
For the 1271A setting, the total count rate is 189 147 cts/s (STIS.sp.1008615) with the Synthetic spectrum normalized to the measured flux of 1.10e-10 at 1320 A, and it is 143 094 cts/s (STIS.sp.1008610) with the IUE spectrum, the difference coming from the depth and width and the very broad Lyman alpha stellar line. We are therefore confident that the total count rate will not exceed the MAMA bright limit of 200 000 cts/s for the originally planned central wavelengths 1271A and 1489A.
In some of the adjacent orders however the predicted countrates are somewhat higher: for central wavelength 1307A the ETC predicts 201 881(STIS.sp.1010028) and for 1453A, the ETC predicts 221 904 cts/s (STIS.sp.0008). We cannot threfore use these two settings. On the other hand, the longer-wavelength setting at 1598A and the previous setting at 1234 A give total count rates of respectively 132 252 cts/s (STIS.sp.1012937) and 101 493 (STIS.sp.1010029), we will thus adopt these settings.

Timing requirements -
For the E140H observations including the O I line at 1302 A, (central wavelength 1234 A and 1271A), it would be preferable to avoid observing periods when the Earth's atmosphere has the same projected velocity as the local neutral ISM in the direction of HD~32309 so that we can avoid contamination of the O I (and N I) interstellar lines by telluric lines. Following Gry & Jenkins (2014), the predicted heliocentric velocity of the local cloud is +20 km/s, and secondary components may be blue-shifted by up to -27 km/s. So to stay on the safe side, we prefer to perform this observation when the telluric velocity is lower than -7 km/s, which occurs from Dec 21 to May 14. Fortunately, this includes the longest schedulability period for our target in Cycle 25, 117 days from Dec 27, 2017 to Apr 22, 2018.

Visit

Proposal 15203, Visit 01, implementation Wed Jul 26 23:02:22 GMT 2017

Diagnostic Status: No Diagnostics

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

Special Requirements: BETWEEN 21-DEC-2017:00:00:00 AND 14-MAY-2018:00:00:00

Fixed Targets

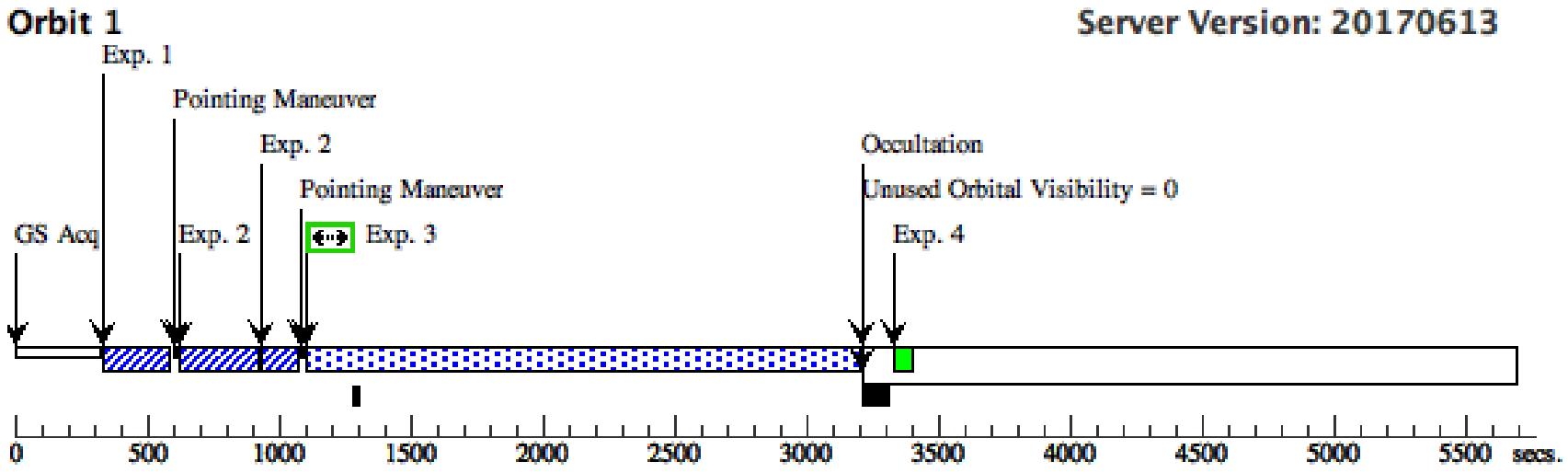
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HD32309	RA: 05 01 25.5805 (75.3565854d) Dec: -20 03 6.91 (-20.05192d) Equinox: J2000	Proper Motion RA: 36.43 mas/yr Proper Motion Dec: -16.46 mas/yr Parallax: 0.01648" Epoch of Position: 2000	V=4.894	Reference Frame: ICRS

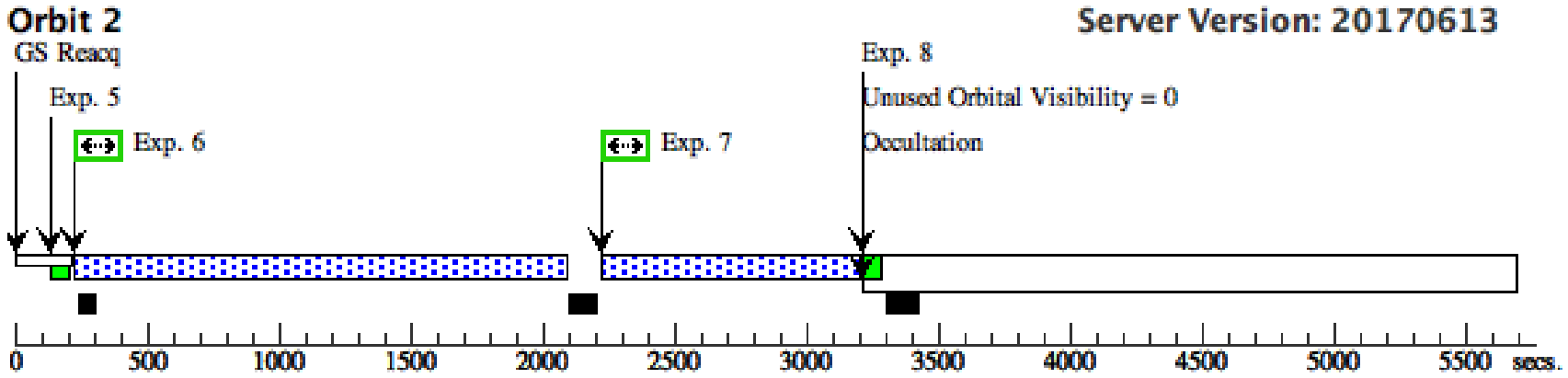
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Extended=NO

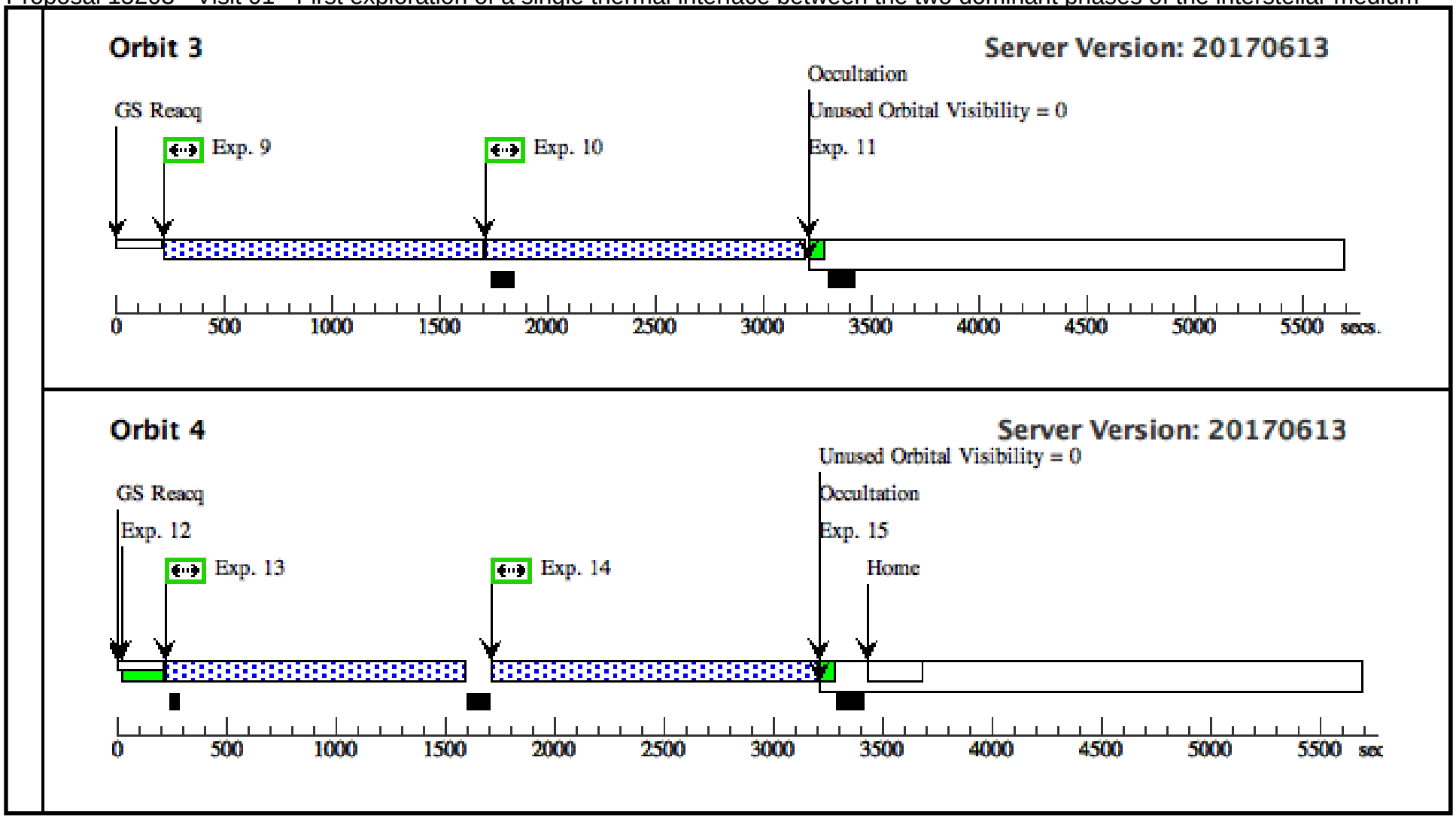
Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQforHD 32309 (STIS.ta.100 9999)	(1) HD32309	STIS/CCD, ACQ, F28X50OII	MIRROR				0.1 Secs (0.1 Secs) *[==>]*	***[1]***
2	ACQ/PEAK for HD3230 9 (STIS.sp.10 12906)	(1) HD32309	STIS/CCD, ACQ/PEAK, 0.2X0.05ND	MIRROR				0.1 Secs (0.1 Secs) *[==>]*	***[1]***
3	E140H1271 (STIS.sp.10 08610)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1271 A				1931 Secs (1931 Secs) *[==>]*	***[1]***
4	wavecal127 1	WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1271 A				*[==>]*	***[1]***
5	wavecal127 1	WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1271 A			Sequence 5-6 Non-In t in Visit 01	*[==>]*	***[2]***
6	e140H1271 (STIS.sp.10 08610)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1271 A			Sequence 5-6 Non-In t in Visit 01	1859 Secs (1859 Secs) *[==>]*	***[2]***
7	E140H1234 (STIS.sp.10 10029)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A	WAVECAL=NO			848 Secs (848 Secs) *[==>]*	***[2]***
8	wavecal123 4	WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	***[2]***
9	E140H1234 (STIS.sp.10 10029)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				1470 Secs (1470 Secs) *[==>]*	***[3]***
10	E140H1234 (STIS.sp.10 10029)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				1471 Secs (1471 Secs) *[==>]*	***[3]***
11	wavecal123 4	WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1234 A				*[==>]*	***[3]***
12	wavecal148 9	WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1489 A			Sequence 12-13 Non -Int in Visit 01	*[==>]*	***[4]***
13	E140H1489 (STIS.sp.10 08100)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1489 A			Sequence 12-13 Non -Int in Visit 01	1354 Secs (1354 Secs) *[==>]*	***[4]***
14	E140H1598 (STIS.sp.10 12937)	(1) HD32309	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1598 A				1353 Secs (1353 Secs) *[==>]*	***[4]***
15	wavecal159 8	WAVE	STIS/FUV-MAMA, ACCUM, 0.2X0.09	E140H 1598 A				*[==>]*	***[4]***

Orbit Structure



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Orbit 4
Server Version: 20170613
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Exp. 14
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