13838 - UV Mapping of the Shocks in the Extremely Collimated Outflows of the Proto-Planetary Nebula Hen 3-1475

Cycle: 22, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Xuan Fang (PI) (ESA Member) (Contact)	**Instituto de Astrofisica de Andalucia (IAA)**	**fangx@iaa.es**
Dr. Ana Ines Gomez De Castro (CoI) (ESA Member)	Universidad Complutense de Madrid	aig@mat.ucm.es
Dr. Martin A. Guerrero (CoI) (ESA Member)	Instituto de Astrofisica de Andalucia (IAA)	mar@iaa.es
Mr. Jesus A. Toala (CoI) (ESA Member)	Instituto de Astrofisica de Andalucia (IAA)	toala@iaa.es
Dr. Angels Riera (CoI) (ESA Member)	Universitat Politecnica de Catalunya	angels.riera@upc.edu

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) HEN3-1475	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	2	22-Oct-2014 21:09:48.0	yes

2 Total Orbits Used

ABSTRACT

In astrophysical environments, shocks are one of the key mechanisms to generate ionized material. These shocks arise mainly from the interaction between high velocity outflows/jets and the surrounding medium. Collimated outflows have been observed in a vast variety of objects including planetary nebulae (PNe) and their precursors, proto-planetary nebulae (PPNe), which are thought to be a crucial stage for PN structure formation.

Hen 3-1475 is a PPN with extremely collimated, high-velocity outflows and an S-shaped string of point-symmetric knots. X-ray emission has been detected in the innermost knots, and HST STIS high-spatial resolution optical spectroscopy has shown that the knots are shock-excited. A time-dependent ejection velocity model has been invoked to explain the observed kinematics and morphology. We propose to obtain HST STIS long-slit UV spectroscopy of Hen 3-1475 using the G140L and G230L gratings. This program will for the first time enable morphological studies of Hen 3-1475 in UV lines. The STIS UV spectrum will be analyzed in conjunction with archival STIS optical and Chandra X-ray data. Detailed hydro-dynamical simulations will be developed based on the multi-wavelength observations to investigate the formation and excitation of knots in fast outflows. Through this program, we will gain a deep understanding of the morphology, kinematics and excitation mechanisms in Hen 3-1475 and set up a benchmark for the morphological study of PPNe.

OBSERVING DESCRIPTION

PHASE I

The requested observations are aimed at obtaining HST STIS FUV and NUV spectra of the S-shaped string of knots embedded in the extremely collimated outflows of the proto-planetary nebula (PPN) Hen 3-1475. The instrumental setup will allow us to obtain two-dimensional maps of the nebula in all emission lines within the spectral range 1150-3180 A, such as O IV] 1403, N III] 1750, C IV 1550, and C III] 1908. For scientific purposes, it is mandatory to align the source symmetry axis as close as possible to the spatial axis of the detector.

The original (Phase I) proposal requested the use of STIS slitless spectroscopy with two different setups:
- G140L in the wavelength range 1150-1730 A (2500 sec exposure)
- G230L in the wavelength range 1570-3180 A (2000 sec exposure)

These observations can be carried out within two orbits (one for each of the two gratings) of one single visit. During the observations, the spatial axes of the STIS/FUVMAMA and STIS/NUVMAMA detectors are oriented along the nebular axis at position angle (PA) ~130 degrees (or ~310 degrees). The PA variation tolerance is +/-10 degrees.

PHASE II

The proposed observations, however, are hampered by the bright geo-coronal Lyman-alpha emission at 1216 A. The HST STIS Exposure Time

Calculator (ETC v22.2) predicts that the brightness limits of the STIS/FUVMAMA detector will be exceeded at an exposure time of 100 sec, if the MAMA Clear (slitless) mode is chosen. Besides, the strong geo-coronal emission will illuminate the whole STIS/FUVMAMA detector in the slitless mode, increasing the background level and reducing the sensitivity of the observations.

APERTURE = 52x2 long slit

Our contact scientist (CS), Dr. Julia Christine Roman-Duval, suggested us to change from the original slitless mode to the 52x2 long slit (2" width). Given the spatial extent of our target (~20"x2"), a 2" wide long slit will significantly reduce the impact of the geo-coronal emission, while still fulfilling our scientific purposes. Following the CS' advice, we thus require to use the 52"x2" long slit instead of the slitless mode.

ORIENT = 174 +/-4 (or 354 +/-4)

The change in the aperture poses additional constraints on the orientations of the instrument, so that the source is included within the 52x2 long slit aperture. We have used the available HST WFPC2 and WFC3 images of our source to derive the ORIENT ranges that allow us to carry out the requested science. In order to keep our target well within the long slit, the slit position angle can only vary within 4 degrees (while it was 10 degrees originally in Phase I) of the nebular axis, PA=129 degrees (or PA=309 degrees), which corresponds to ORIENT=174 (or PA=354) +/-4 degrees. We then checked how the scheduling of the observations will be affected by this further ORIENT constraints using the Phase II Astronomer's Proposal Tool (APT v22.2) by running the Orbit and Visit Planners. The scheduling of the observations does not change significantly for these new constraints. We emphasize that there is only one single visibility window for the observations to be scheduled, from June 15 00:00, 2015 to June 22 23:59, 2015.

MODE = TIME-TAG

The brightness of our target (V = 12.87) allows the use of the TIME-TAG mode in the observations (communications with the CS, Dr. Julia Christine Roman-Duval). This mode will allow us to scrutinize the data for periods of high airglow level.

EXPOSURE TIMES: G230L=2100 sec, G140L=2800 sec

In order to make the observations efficient, we arrange our exposures as follows: STIS/NUVMAMA G230L in the first orbit, and STIS/FUVMAMA G140L in the second orbit. Fine tuning with the APT Orbit and Visit Planners finally allows a 2100 sec exposure with the grating G230L in the first orbit, and a 2800 sec exposure with the grating G140L in the second orbit. The two orbits are included in one single visit.

For the STIS/NUVMAMA (G230L) 52x2 long-slit observations, the STIS Spectroscopic ETC (ETC ID: 618488) predicts a signal-to-noise ratio (SNR) of 10 (per resolution element) for the C III] 1908 line for an integration time of 2100 sec. The count rate of the entire detector will be 3038 counts/sec, well below the STIS/NUVMAMA brightness limit (30000 counts/sec). Here the C III] 1908 line flux, 1.2E-13 erg/cm^2/s, was measured from an earlier IUE low-resolution spectrum (e.g., SWP35860LL), and we assumed that the UV line fluxes all come from the six point-symmetric knots of Hen 3-1475.

For the STIS/FUVMAMA (G140L) 52x2 long slit observations, the STIS Spectroscopic ETC (ETC ID: 618508) predicts an SNR of 16 (per resolution element) for the O IV] 1403 line for an exposure time of 2800 sec (also based on the IUE spectrum SWP35860LL). The count rate of the entire detector will be 2640 counts/sec, also well below the STIS/FUVMAMA brightness limits.

SOURCE ACQ

A bright, compact region at the core of Hen 3-1475 will be used for target acquisition. The size of this region is about 0.3 arcsec in diameter. Its brightness can be estimated from the total R magnitude of the source, which is 11.7 mag. This region encompasses about 1/4 of the total flux of the nebula, thus its magnitude is about 13.2 mag. This corresponds to a surface brightness of 11.4 mag/arcsec^2. The STIS Target Acquisition ETC (ETC ID: 619178) shows that an exposure of 3 sec through the longpass F28X50LP filter will produce a high SNR, greater than 200, while being far from the saturation limit.

Similarly, we have used the optical spectrum of the innermost region of Hen 3-1475 (Riera et al. 1995, A&A, 302, 137) to find a continuum flux level of 8.0E-15 erg/cm^2/s/A at the wavelength of the longpass F28X50LP filter. Assuming an emitting region of the size 0.3 arcsec in diameter, the surface brightness will be 1.1E-13 erg/cm^2/s/A/arcsec^2. Adopting a flat continuum, the STIS Target Acquisition ETC (ETC ID: 619179)

predicts a similarly high SNR.

Since the STIS ACQ is accurate to 0.5 pixel (=0.025"), there is no need for an additional ACQ/PEAK exposure when the 2" wide slit is used (communications with the CS, Dr. Julia Christine Roman-Duval).

Bright Object Tool (BOT)

We run the BOT in APT v22.2 and it found all sources in the STIS field of views to be safe, except one. Actually, this diffuse source, whose status is claimed to be unknown, is our source target, Hen 3-1475.

Visit

Proposal 13838, Visit (01), implementation Thu Oct 23 01:09:50 GMT 2014

Diagnostic Status: No Diagnostics

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

Special Requirements: ORIENT 170D TO 178 D; ORIENT 350D TO 358 D

Comments: HST STIS FUV and NUV long-slit spectroscopy of proto-planetary nebula Hen 3-1475

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	HEN3-1475	RA: 17 45 14.1900 (266.3091250d) Dec: -17 56 46.90 (-17.94636d) Equinox: J2000		V=12.87 B=13.84, R=11.70, the total flux of the C III] 1907, 1909 lines is 1.2e-13 ergs cm^-2 s^-1	Reference Frame: ICRS

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ACQ (STIS.ta.619178)	(1) HEN3-1475	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=DIFFUSE; DIFFUSE-CENTER=FLUX-CENTROID; CHECKBOX=11			3 Secs (3 Secs) *[==>]*	***[1]***
2	G230L/2376 (STIS.sp.618488)	(1) HEN3-1475	STIS/NUV-MAMA, TIME-TAG, 52X2	G230L 2376 A	BUFFER-TIME=500			2150 Secs (2100 Secs) *[==>2100.0 Secs]*	***[1]***
3	G140L/1425 (STIS.sp.618508)	(1) HEN3-1475	STIS/FUV-MAMA, TIME-TAG, 52X2	G140L 1425 A	BUFFER-TIME=500			2500 Secs (2800 Secs) *[==>2800.0 Secs]*	***[2]***

Orbit Structure