15499 - The Mystery of ASASSN-15lh

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) ASASSN-15LH	WFC3/UVIS	2	27-Apr-2020 18:00:16.0	yes
51	(1) ASASSN-15LH	WFC3/UVIS	1	27-Apr-2020 18:00:17.0	yes
02	(1) ASASSN-15LH	WFC3/IR	1	27-Apr-2020 18:00:18.0	yes

4 Total Orbits Used

ABSTRACT

ASASSN-15lh is the most luminous optical transient ever detected. Yet its nature is unclear. It was first thought to be a supernova. However, its host shows little sign of star formation, and the transient has remained extremely hot for nearly two years, making a supernova origin seem less likely. Aternatively, ASSASN-15lh may be a flare caused by the tidal disruption of a star that has flown too close to a supermassive black hole. However, this model is also far from an easy fit. The luminosty of the host's bulge implies a black hole mass so large that a star would almost

certainly be swallowed before disrupted, unless the the black hole is spinning relativisitically. Furthermore, the double-humped shape of the light curve seen in the UV is highly unusual for a tidal disrution flare (TDF). Here we propose observations using nearly the entire wavelength range of HST to elucidate the nature of this object. We will be able to determine the location of the transient with respect to the host bulge light, and thus the likely position of the black hole, to ~20 pc, or nearly an order of magnitude better than the present best estimate. We will measure the temperature of the transient, which may prove too high for a supernova at such a late time, and study the host star-formation, which is essential for producing a supernova. Additionally, we will attempt to confirm (or refute) the apparent evidence for a recent merger we have found in the extant HST images. A merger should greatly enance the rate of stellar disruptions by a central black hole. Together these obsevations will dramatically improve our undertanding of this most extraordinary transient.

OBSERVING DESCRIPTION

Our program has three primary goals: 1) determine the late time temporal behavior of a tidal disruption flare, and in particular determine whether it remains hot, in contrast to the behavior of known supernovae. 2) Determine the offset of the transient from the nucleus of the galaxy; a large detected offset would challenge the TDF scenario. 3) Determine whether the disturbed morphology in the galaxy is associated with tidal features, indicative of a somewhat recent merger.

Goal 1) Determining the late-time temporal behavior of the flare will be accomplished through UV imaging. The F225W and F336W filters are well matched to the Swift UVM2 and U filters respectively. In one orbit of observing we expect to be able to measure the relative flux in the F225W and F336W filters to nearly one percent. This, in principle, allows us to measure the temperature of the source to a precision of about 100K. Our calibration errors to the Swift filters will be larger than this, but this means we will be able to detect any meaningful change in temperature. Furthermore, assuming we find that the temperature has been nearly constant, we will be able to scale off of the UV to estimate the brightness of the transient in the optical and NIR, where it is far harder to disentangle the transient from the host. We can compare this estimate with the one we will obtain by extrapolating the known decay of the transient's optical magnitude with time. The depth of these observations will also allow us to effectively search for UV emission from the galaxy. We would easily detect the light from the host even if it was uniformly distributed over the roughly 2"x1" size of the galaxy. In the event that the host UV light (seen in the spectrum of Figure 2) is centered tightly in the nucleus, we will know, and be able to adjust for it in the temperature estimate (and also able to include it in our error estimates). Finally the UV imaging may help us to understand the possible tidal (or dust or tidal plus dust) feature seen in the extant F606W imaging.

Goal 2) Determining the offset of the transient from the nucleus of the galaxy will be accomplished by UVIS and NIR imaging. For this goal we will use two filters, the UVIS F606W and the NIR F140W. The field was observed twice previously in F606W, and subtraction of the Cycle 26 image from an earlier F606W image will give us the location of the transient. We will be able to align very accurately to the earlier F606W image (to 2 mas if we ignore the roll angle; if we use the same orientation and placement as an earlier observation we should do better than 1 mas, as the field distortions are quite stable). However, in Cycle 26 the transient is likely to contribute between 15 and 30\% of the light within a one pixel radius in F606W, even if it is on the brightest part of the host. Thus the unknown exact contribution of the transient will limit our ability to determine the precise offset. Nonetheless, we will definitely do better than 10 mas, and quite possibly better than 5 mas. We will also observe the host with the NIR F140W. We estimate that the transient will only be between 1.5 and 2\% of the peak flux of the host in Cycle 26. Our ability to determine the offset between the transient and the nucleus will thus be determined by our ability to transfer the F606W image to the F140W image. This will require us to use a full chip readout in F606W, so that we have enough stars to do the transfer (galaxy centroids can vary between the optical and NIR). Our ability to determine the offset in the IR will be limited by our knowledge of the NIR distortions, which have an rms of 7 mas. Thus our ability to determine the offset will be no worse than 7 mas. Furthermore, we will have two largely independent measurements of the offset, as the error in F140W will be dominated by our knowledge of the field distortions, while the error in F606W will be dominated by the uncertainty in the transient flux remaining in the Cycle 26 image. In order to accomplish these precise astrometric measurements we will need to do four-point dithering. Because readout of the full UVIS chip is slow, short exposures waste time waiting for the readout to complete. Therefore we will require the better part of a single orbit for the F606W imaging. We will thus need one orbit each for the F606W and F140W filters.

Goal 3) Determining the nature of the disturbed morphology of the host will be done by comparing the multiwavelength observations. The imaging that we are doing to accomplish the first two goals will give us multiwavelength coverage from 225 ns to 1400 nm. This will allow us to distinguish differences in stellar surface density, star formation and dust. We note that short snapshot F814W and F555W images were recently taken of the ASASSN-15lh field. However, we have examined these images, and they are not sufficiently deep to see the disturbed morphology visible in the 2400s F606W image. Thus further observations are clearly need to resolve the mystery of ASASSN-15lh.

Visit

Proposal 15499, Optical / UV Imaging (01), failed Mon Apr 27 22:00:18 GMT 2020

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: SAME ORIENT AS 02; GROUP 01,02 WITHIN 7D

Diagnostics

(Optical / UV Imaging (01)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Optical / UV Imaging (01)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(3)
(3)	Pattern Type=WFC3-UVIS-DITHER-LINE Purpose=DITHER Number Of Points=2 Point Spacing=0.145 Line Spacing=	Coordinate Frame=POS-TARG Pattern Orientation=46.84 Angle Between Sides= Center Pattern=false		(1), (2)

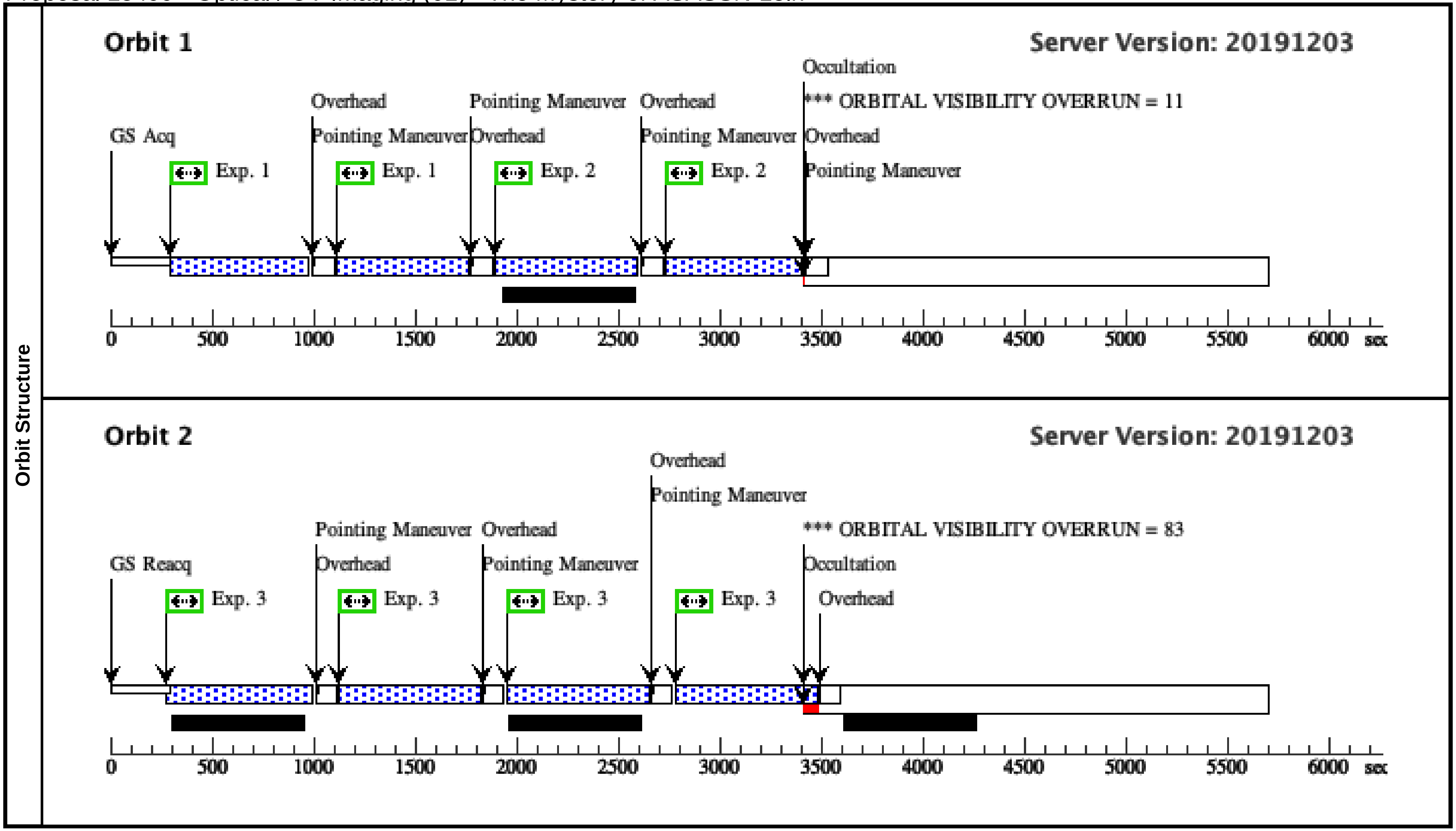
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	ASASSN-15LH	RA: 22 02 15.4500 (330.5643750d) Dec: -61 39 34.64 (-61.65962d) Equinox: J2000		V=20	Reference Frame: SIMBAD

Comments: Replicating coordinates from original observation
Category=EXT-STAR
Description=[ACCRETION DISK]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) ASASSN-15LH	WFC3/UVIS, ACCUM, UVIS2	F225W	FLASH=11		Pattern 3, Exps 1-1 in Optical / UV Imaging (01) (3)	650 Secs (1300 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
2		(1) ASASSN-15LH	WFC3/UVIS, ACCUM, UVIS2	F336W	FLASH=11		Pattern 3, Exps 2-2 in Optical / UV Imaging (01) (3)	675 Secs (1350 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
3		(1) ASASSN-15LH	WFC3/UVIS, ACCUM, UVIS2	F606W			Pattern 1, Exps 3-3 in Optical / UV Imaging (01) (1)	700 Secs (2800 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[2]***


Orbit Structure
Orbit 1
Server Version: 20191203
Occultation
*** ORBITAL VISIBILITY OVERRUN = 11
Overhead
Pointing Maneuver
Pointing Maneuver
Overhead
Overhead
Pointing Maneuver
Overhead
Pointing Maneuver
GS Acq
Exp. 1
Exp. 1
Exp. 2
Exp. 2
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec
Orbit 2
Server Version: 20191203
Overhead
Pointing Maneuver
Pointing Maneuver
Overhead
*** ORBITAL VISIBILITY OVERRUN = 83
Overhead
Pointing Maneuver
Occultation
GS Reacq
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Overhead
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
sec

Visit

Proposal 15499, Optical / UV Imaging (51), implementation Mon Apr 27 22:00:18 GMT 2020

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 254D TO 254 D

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=false		(1)

Fixed Targets

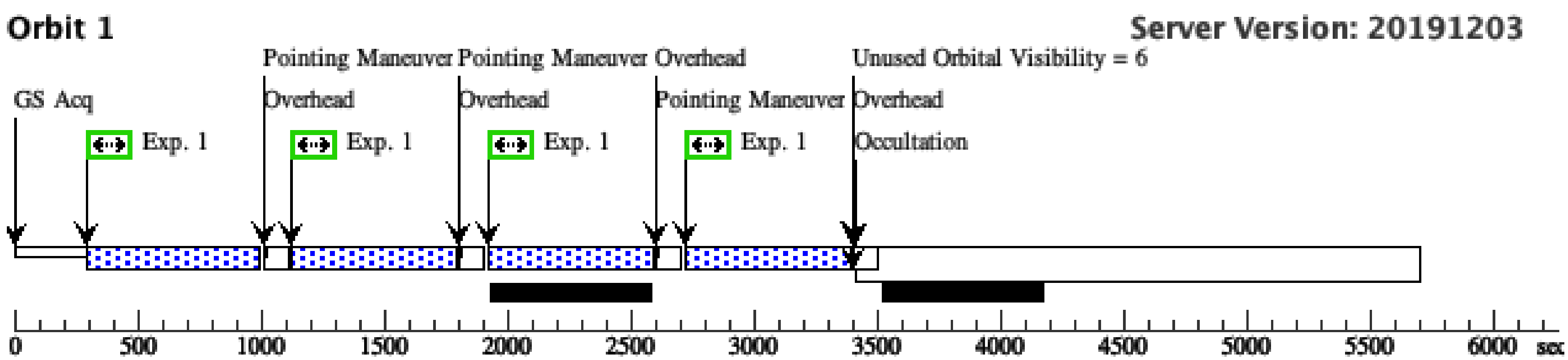
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	ASASSN-15LH	RA: 22 02 15.4500 (330.5643750d) Dec: -61 39 34.64 (-61.65962d) Equinox: J2000		V=20	Reference Frame: SIMBAD

Comments: Replicating coordinates from original observation
Category=EXT-STAR
Description=[ACCRETION DISK]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) ASASSN-15LH	WFC3/UVIS, ACCUM, UVIS2	F606W			Pattern 1, Exps 1-1 in Optical / UV Imaging (51) (1)	670 Secs (2680 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	*[1]*

Orbit Structure



Proposal 15499 - IR Imaging (02) - The Mystery of ASASSN-15lh

Visit

Proposal 15499, IR Imaging (02), completed — Mon Apr 27 22:00:18 GMT 2020

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=0.572 Line Spacing=0.365	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(1)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	ASASSN-15LH	RA: 22 02 15.4500 (330.5643750d) Dec: -61 39 34.64 (-61.65962d) Equinox: J2000		V=20	Reference Frame: SIMBAD

Comments: Replicating coordinates from original observation
Category=EXT-STAR
Description=[ACCRETION DISK]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) ASASSN-15LH	WFC3/IR, MULTIACCUM, IR	F140W	SAMP-SEQ=STEP100; NSAMP=13		Pattern 2, Exps 1-1 in IR Imaging (02) (2)	699.232615 Secs (2796.93 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***

Orbit Structure