



## 15599 - Catching the Soft State of the Black Hole Transient MAXI J1820+070f

Cycle: 25, Proposal Category: GO/DD

(Availability Mode: SUPPORTED)

### INVESTIGATORS

<i>Name</i>	<i>Institution</i>	<i>E-Mail</i>
<b>Prof. Christian Knigge (PI) (ESA Member) (Contact)</b>	<b>University of Southampton</b>	<b>c.knigge@soton.ac.uk</b>
Dr. Diego Altamirano (CoI) (ESA Member)	University of Southampton	d.altamirano@soton.ac.uk
Dr. Poshak Gandhi (CoI) (ESA Member)	University of Southampton	p.gandhi@soton.ac.uk
Prof. Joseph Patterson (CoI) (AdminUSPI)	Columbia University in the City of New York	jop@astro.columbia.edu
Dr. Robert I. Hynes (CoI)	Louisiana State University and A & M College	rih@phys.lsu.edu
Dr. Knox S. Long (CoI)	Eureka Scientific Inc.	long@stsci.edu

### VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) MAXI-J1820+070	STIS/CCD STIS/FUV-MAMA STIS/NUV-MAMA	3	10-Jul-2018 16:00:20.0	yes

3 Total Orbits Used

### ABSTRACT

On March 11, MAXI/GSC detected a new X-ray transient, MAXI J1820+070. Since then, the system has become one of the brightest black-hole X-ray binaries (BHXRBs) ever seen and is currently the target of an extensive multi-wavelength campaign. Far- and near-ultraviolet spectroscopy is critical to this, and we were therefore awarded two visits on the source with HST/STIS in order to obtain this. BHXRBs usually undergo dramatic "state transitions" during the outburst, so one key goal was to catch first the "hard state" (Visit 1) and then the "soft state" (Visit 2). Unfortunately, the

post-maximum evolution of the source indicated that it would not undergo a transition to the soft state at all. We thus triggered Visit 2 as the system was fading, in order to obtain a least a second hard-state spectrum. In perfect accordance with Murphy's Law, MAXI J1820+070 re-brightened almost immediately after our trigger. It is right now undergoing the hard-to-soft state transition we have been waiting for -- just days after Visit 2 was successfully executed. Since the ability to compare hard- and soft-state spectra is crucial -- e.g. disk winds producing P Cygni features are only expected in the soft state -- we propose to obtain one additional epoch of UV spectroscopy. This will allow us to detect such wind signatures, if they exist, and to test if the broad-band UV-optical-IR SED changes during the state transition, as does the X-ray SED. In addition, all of our data will be taken in TIME-TAG mode, allowing us to search for the first time for stochastic and (quasi-)periodic variability, as well as interband time lags, in the UV emission from a soft-state BHXRB.

### **OBSERVING DESCRIPTION**

We will visit V404 Cyg three times with HST. The first and third visit will each consist of 5 consecutive HST orbits, during which we will carry out time-resolved far-UV spectroscopy with the COS/G140L instrument/grating combination. We will use the 1105 Å setting for all of these observations to achieve continuous wavelength coverage between 1121 Å and 2148 Å. The TIME-TAG mode of COS will provide sufficient time resolution to capture variability on the dynamical time-scale within the accretion disk. COS is preferred to STIS in the far-UV despite due to its much higher sensitivity in this waveband.

The second visit will consist of 2 consecutive HST orbits, during which we will obtain time-resolved near-UV spectroscopy with the STIS/NUV-MAMA/G230L instruments/detector/grating combination. This gives continuous wavelength coverage between 1570 Å and 3180 Å, again at a time resolution sufficient to resolve fast flickering.

Recent near-UV photometry obtained by Swift/UVOT shows that  $F_{\lambda, \text{NUV}} \sim 1-5 \times 10^{-16} \text{ erg/cm}^2/\text{s}/\text{Å}$ . (Motta et al. 2015b), where the near-UV measurement corresponds to the UVW1 or UVW2 filters, which have central wavelength of 2600 Å and 1900 Å, respectively. Since the intrinsic SED is likely to be blue, but subject to considerable reddening, far-UV and near-UV fluxes will probably be comparable. Based on these numbers, and allowing for overheads, we then estimate that 10 HST orbits of far-UV spectroscopy will yield a combined spectrum with S/N  $\sim 5-15$  per resolution element at 1500 Å. Similarly, our 2 orbits of near-UV spectroscopy will yield a combined spectrum with S/N  $\sim 5-15$  per resolution element at 2800 Å.

There are no safety concerns for the COS or STIS detectors. In the near-UV, the existing Swift/UVOT observations show that the system is nowhere

## Proposal 15599 (STScI Edit Number: 1, Created: Tuesday, July 10, 2018 3:00:21 PM EST) - Overview

near bright enough to threaten detector damage. No empirical data exists so far in the far-UV, but even the most extreme plausible extrapolation from the near-UV to the far-UV -- assuming that both near-UV and far-UV emission lie on the Rayleigh-Jeans tail of the disk spectrum ( $F_{\lambda} \sim \lambda^{-4}$ ) -- yields local and global count rates that remain well below the bright object limits.

We will use an imaging target acquisition with Mirror B as the best compromise between efficiency and instrument safety. With this set-up, a 1 min ACQ/IMAGE target acquisition exposure yields S/N  $\sim 30$ -60 depending on the detailed SED shape, and the count rate in the brightest pixel never exceeds 8 c/s, well below the bright object limit.

The observations should ideally take place as soon as possible, in order to ensure that we catch the system before it decays too much. We therefore request that the observations should be scheduled in the next available scheduling window (July 4-13) and preferably near the start of this window.

We also request that the near-UV visit should take place between the two far-UV visits and that all three visits should take place as close in time as possible. This will allow us to construct a near-simultaneous global SED.

Several of us are leaders/members of ongoing monitoring campaigns at other wavelengths, so we can rely on existing/approved programs to obtain (near-)simultaneous coverage across the entire frequency range. In order to facilitate the scheduling of the HST program, we are not requesting any of these auxiliary observations to be formally linked to the HST observations. Instead, we will simply make a best effort to achieve obtain the widest possible range of auxiliary observations as close as possible to the time of the HST observations.

We finally note that, given the strong variability currently seen at all wavelengths and on all time-scales (e.g. Ferrigno et al. 2015; Motte et al. 2015ab; Hynes et al. 2015; Hardy et al. 2015; Tetarenko et al. 2015), it is impossible to predict with certainty whether the system is likely to be detectable in the far-UV in early July. We are therefore happy to work with STScI to mitigate the risk of a non-detection. For example, it may be possible to implement a "dead-man's switch", whereby the HST observations will only be executed if Swift/UVOT near-UV photometry closer to the HST scheduling window indicates a significant likelihood of success.

Proposal 15599 - Visit 01 - Catching the Soft State of the Black Hole Transient MAXI J1820+070f

Tue Jul 10 20:00:21 GMT 2018

Visit	<b>Proposal 15599, Visit 01</b> <b>Diagnostic Status: No Diagnostics</b> Scientific Instruments: STIS/NUV-MAMA, STIS/CCD, STIS/FUV-MAMA Special Requirements: SCHED 100%																											
	Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Fluxes</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>MAXI-J1820+070</td> <td>RA: 18 20 26.4300 (275.1101250d) Dec: +07 10 11.80 (7.16994d) Equinox: J2000</td> <td>Proper Motion RA: 0 mas/yr Proper Motion Dec: 0 mas/yr Epoch of Position: 2018</td> <td>V=12</td> <td>Reference Frame: ICRS</td> </tr> <tr> <td colspan="6"> <i>Comments:</i>                      Category=STAR                      Description=[ACCRETION DISK, WIND, X-RAY NOVAE, X-RAY TRANSIENT]                      Extended=NO                 </td> </tr> </tbody> </table>										#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous	(1)	MAXI-J1820+070	RA: 18 20 26.4300 (275.1101250d) Dec: +07 10 11.80 (7.16994d) Equinox: J2000	Proper Motion RA: 0 mas/yr Proper Motion Dec: 0 mas/yr Epoch of Position: 2018	V=12	Reference Frame: ICRS	<i>Comments:</i> Category=STAR Description=[ACCRETION DISK, WIND, X-RAY NOVAE, X-RAY TRANSIENT] Extended=NO				
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Exposures	#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit																		
	1		(1) MAXI-J1820+070	STIS/CCD, ACQ, 50CCD	MIRROR				0.1 Secs (0.1 Secs) [==>]	[1]																		
	2	UV-1 (STIS.sp.11 73361)	(1) MAXI-J1820+070	STIS/FUV-MAMA, TIME-TAG, 0.2X0.2	E140M 1425 A	BUFFER-TIME=50 0			2000 Secs (2151 Secs) [==>2151.0 Secs ]	[1]																		
	3	UV-1 (STIS.sp.11 73361)	(1) MAXI-J1820+070	STIS/FUV-MAMA, TIME-TAG, 0.2X0.2	E140M 1425 A	BUFFER-TIME=50 0			3000 Secs (2730 Secs) [==>2730.0 Secs ]	[2]																		
	4	UV-1 (STIS.sp.11 73362)	(1) MAXI-J1820+070	STIS/NUV-MAMA, TIME-TAG, 0.2X0.2	E230M 1978 A	BUFFER-TIME=30 0			1000 Secs (1141 Secs) [==>1141.0 Secs ]	[3]																		
	5	UV-1 (STIS.sp.11 73363)	(1) MAXI-J1820+070	STIS/NUV-MAMA, TIME-TAG, 0.2X0.2	E230M 2707 A	BUFFER-TIME=20 0			1000 Secs (1141 Secs) [==>1141.0 Secs ]	[3]																		



