13713 - Observation of Chariklo's rings

Cycle: 22, Proposal Category: GO

(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) CHARIKLORING	WFC3/UVIS	1	07-Oct-2014 21:10:35.0	yes
02	(1) CHARIKLORING	WFC3/UVIS	1	07-Oct-2014 21:10:37.0	yes
03	(1) CHARIKLORING	WFC3/UVIS	1	07-Oct-2014 21:10:39.0	yes

3 Total Orbits Used

ABSTRACT

Dense and sharply confined rings have recently been discovered during a stellar occultation around the small Centaur object Chariklo (Braga-Ribas et al., 2014). This is the first body after the giant planets found to possess a ring system. We propose to use HST to (1) obtain direct images of the rings,

confirming their existence and their orientation, (2) derive multi-wavelength photometry, thus constraining their composition (concerning in particular the presence of water ice), (3) perform for the first time a deep search of small satellites and (4) faint dusty rings around Chariklo, and (5) search for material around another Centaur similar to Chariklo, Chiron, which is known to be surrounded by cometary material and narrow jets. The presence (or absence) of satellites and dusty material around Chariklo will discriminate the various theoretical models that are invoked to explain the origin, evolution and stability of rings around this minor body. The motion of putative Chariklo satellites will also provide an estimation of the mass of the primary, from which its density can be derived, which eventually tells us where the rings are relative to Chariklo's Roche limit.

OBSERVING DESCRIPTION

I. Observations of Chariklo rings

With a diameter of about 250 km, Chariklo subtends 25 milliarcsec (mas) on the sky, while the rings span a diameter of about 800 km (or 80 mas). The expected geometry of the rings at opposition (June 2015), corresponds to an opening angle B=43 deg and position angle P=-64 deg, see Fig. 1. From BR14, the total rings apparent area should represent about 25% of that of Chariklo, while reflecting ~75% of Chariklo's flux as they are about three times brighter. Consequently, each ring ansa will have an estimated flux that represents about 20% of Chariklo's flux in the visible (Fig. 1 - see PDF of Phase I). Taking images with the CCD rows aligned with the ring longer axis, then rotating the telescope by 90 deg and subtracting the resulting images will eliminate Chariklo's contribution and reveal the ring ansae and their position angle. As Chariklo can be considered as a point source with Vmag= 18.5, the ring ansa will each correspond to point sources of Vmag= 20 that appear clearly in the simulation shown in Fig 1 (right panel).

Assuming a ring spectrum similar to that of the Sun (Kurucz G2V), with standard zodiacal light, standard Earth shine light and average Air Glow, the Exposure Time Calculator provides the exposure times for each filter as follows:

- F300X: 200 seconds exposure - aggregate (two exposures) SNR=50 on Chariklo;
- F475X: 7 seconds exposure - SNR=50 (per exposure) on Chariklo;
- F350LP: 170 seconds exposure - SNR=1.4 on Vmag=28 and SNR=3.5 on Vmag=27 with 90% of saturation on Chariklo. ETC SNR assumes no contamination from Chariklo. The limiting magnitudes will get brighter inward of 2 arcsec from the central body

I.1 Target acquisition strategies

The strategy to provide direct images of Chariklo's rings is to choose the roll angle of HST so that the pixel array on the camera is aligned with the apparent ellipse of the rings, see Fig. 1. The ring position angle can be specified for any particular date (at opposition, the position angle will be P=-64 deg). We will dither all exposures using optimal standard patterns based on the total number of exposures for each filter. Since we have a small (7 arcsec) region of interest, we will use the UVIS2-C512C-SUB aperture to permit getting more images per visit. The use of the F475X filter is to detect the rings in the visible, complementing the images on UV taken with the F300X filter. In particular, we want to confirm the water ice spectral slope below 5000 Angstrom, so the use of these two filters is needed. The broader F350LP filter is used for a deep search for additional rings or satellites. The available time in each visit will reach as faint as V=28, or down to a few km in size.

A satellite with orbital radius r_km has a period of T ~ 10^(-4) .(r_km)^1.5 days, estimating Chariko's mass to ~10^19 kg (icy body with radius 125 km). As we can detect satellites between typically 20,000 and 70,000 km from the primary (see discussion above), T ranges from 8 months to about 5 years. During one week, the satellite will move respectively by 3,500 and and 1,900 km, respectively, corresponding to about 9 and 5 pixels for the two extreme cases examined here.
After a few days, we plan to observe Chariklo on two more visits. The time between each visit is dictated by HST for the camera to roll 90 degrees (the U3 angle). Using the same strategy as the first orbit, but with a 90 degrees roll difference on the camera, we can use Chariklo to subtract itself out and remove the wings of the PSF, letting us see the rings and also to try to detect the motion of possible satellites. To confirm a possible detection of satellites, a third visit after a few days is planned, having 0 or 180 degrees roll on the U3 angle (compared to the first orbit). For the three orbits, the same strategy of observation will be used (the only difference is the roll angle).
Time distribution for each of the three orbits, checked to ensure that it fits in a single visibility window, is shown on Table 1A - see PDF of Phase I.

Proposal 13713 - Visit 01 - Observation of Chariklo's rings

Visit

Proposal 13713, Visit 01, implementation Wed Oct 08 01:10:41 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: (none)

Comments: We are searching for objects within 2 arcsec away the central body (Chariklo).

The "ring-broad-band" and "ring-UV" avoid saturation for accurate photometry and colors. The POS-TARG value use for all exposures is set to keep the target away from the bad column in the sub-array. The 2 point dither "pattern 1" is chosen for cosmic ray rejection and to move the target relative to any blemishes in the image. The exposure times in these color observations are set by our SNR requirements without saturation on Chariklo and its rings.

"long-part 1" and "2" are longer exposures for looking for satellites. There is no dithering within these sets but there is a slight dither built in to the second part that mimics the two-point dither pattern while minimizing overhead from the dither operation. This pattern follows the successfull strategy used for Pluto during the search for faint satellites. The exposure times for these images are set to all be identical and to fill the orbit without excessive saturation from the central object.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	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)

Solar System Targets

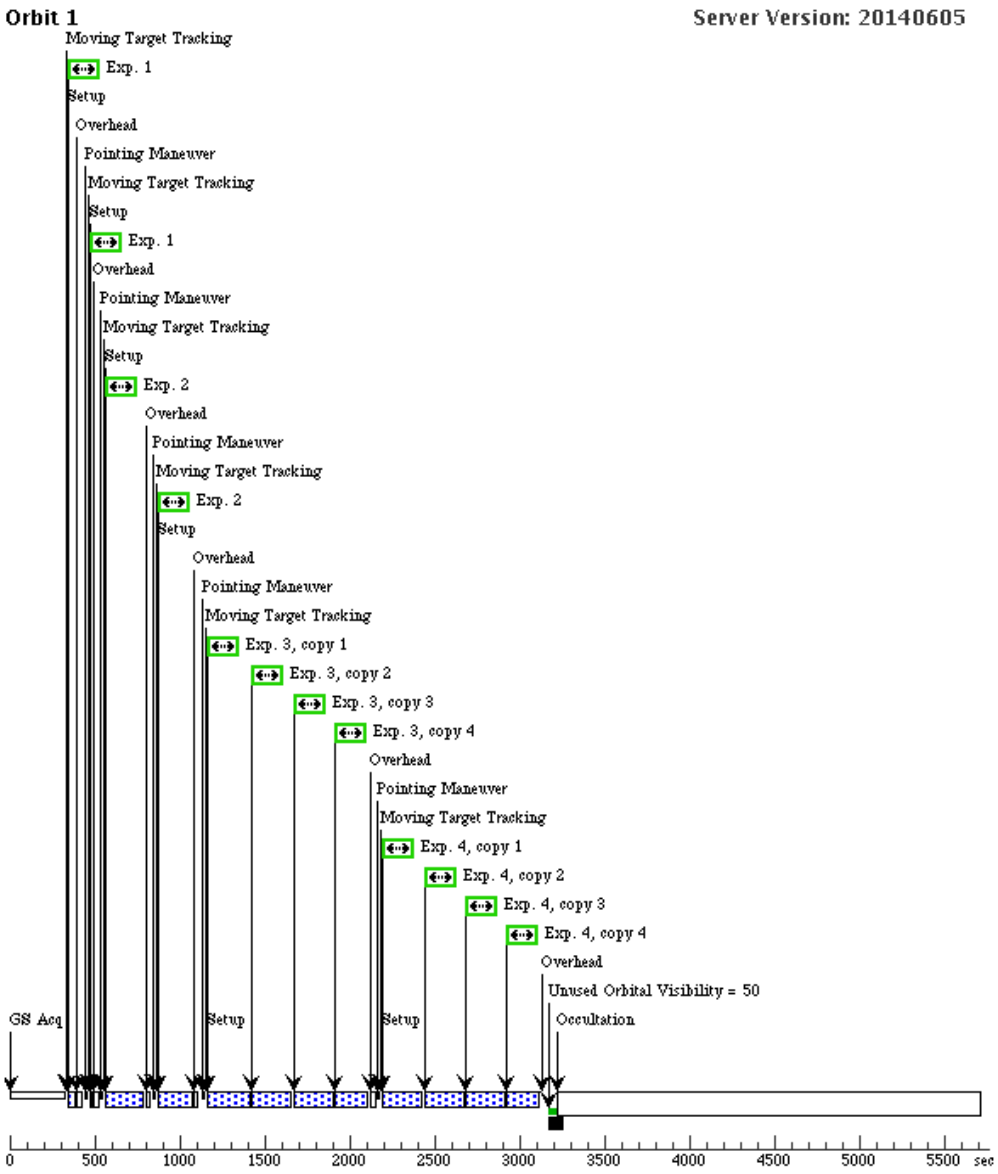
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	CHARIKLORING	TYPE=ASTEROID,A=15.754239376201 95,E=0.1715964458910988,I=23.41166280741038,O=300.3798243316353,W=241.6005157950247,M=60.13086140827895,EQUINOX=J2000,EPOCH=23-MAY-2014:00:00:00,EpochTimeScale=TDB				EARTH

Proposal 13713 - Visit 01 - Observation of Chariklo's rings

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ring-broad-band	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F475X	CR-SPLIT=NO	POS TARG 3.0,0.	Pattern 1, Exps 1-1 in Visit 01 (1)	7 Secs (14 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
2	ring-UV	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F300X	CR-SPLIT=NO	POS TARG 3.0,0.	Pattern 1, Exps 2-2 in Visit 01 (1)	200 Secs (400 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
3	long-part 1	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 3.0,0.0		190 Secs X 4 (760 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***
4	long-part 2	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 3.14,0.14		190 Secs X 4 (760 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***

Orbit Structure



Proposal 13713 - Visit 02 - Observation of Chariklo's rings

Visit

Proposal 13713, Visit 02, implementation Wed Oct 08 01:10:41 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 90D TO 90D FROM 01; AFTER 01 BY 3 D TO 11 D

Comments: We are searching for objects within 2 arcsec away the central body (Chariklo). The design of this visit is identical to visit 1 except for a 90 degree rotation needed to isolate the ring. A timing window is also needed for the satellite search observations. Visits 1 and 2 will comprise the discovery pair for initial orbit estimates and can not be either too close together or too far apart. The values we chose are a compromise between the roll angle difference needed and the estimated motion of satellites around Chariklo.

The "ring-broad-band" and "ring-UV" avoid saturation for accurate photometry and colors. The POS-TARG value use for all exposures is set to keep the target away from the bad column in the sub-array. The 2 point dither "pattern 1" is chosen for cosmic ray rejection and to move the target relative to any blemishes in the image. The exposure times in these color observations are set by our SNR requirements without saturation on Chariklo and its rings.

"long-part 1" and "2" are longer exposures for looking for satellites. There is no dithering within these sets but there is a slight dither built in to the second part that mimics the two-point dither pattern while minimizing overhead from the dither operation. This pattern follows the successfull strategy used for Pluto during the search for faint satellites. The exposure times for these images are set to all be identical and to fill the orbit without excessive saturation from the central object.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	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)

Solar System Targets

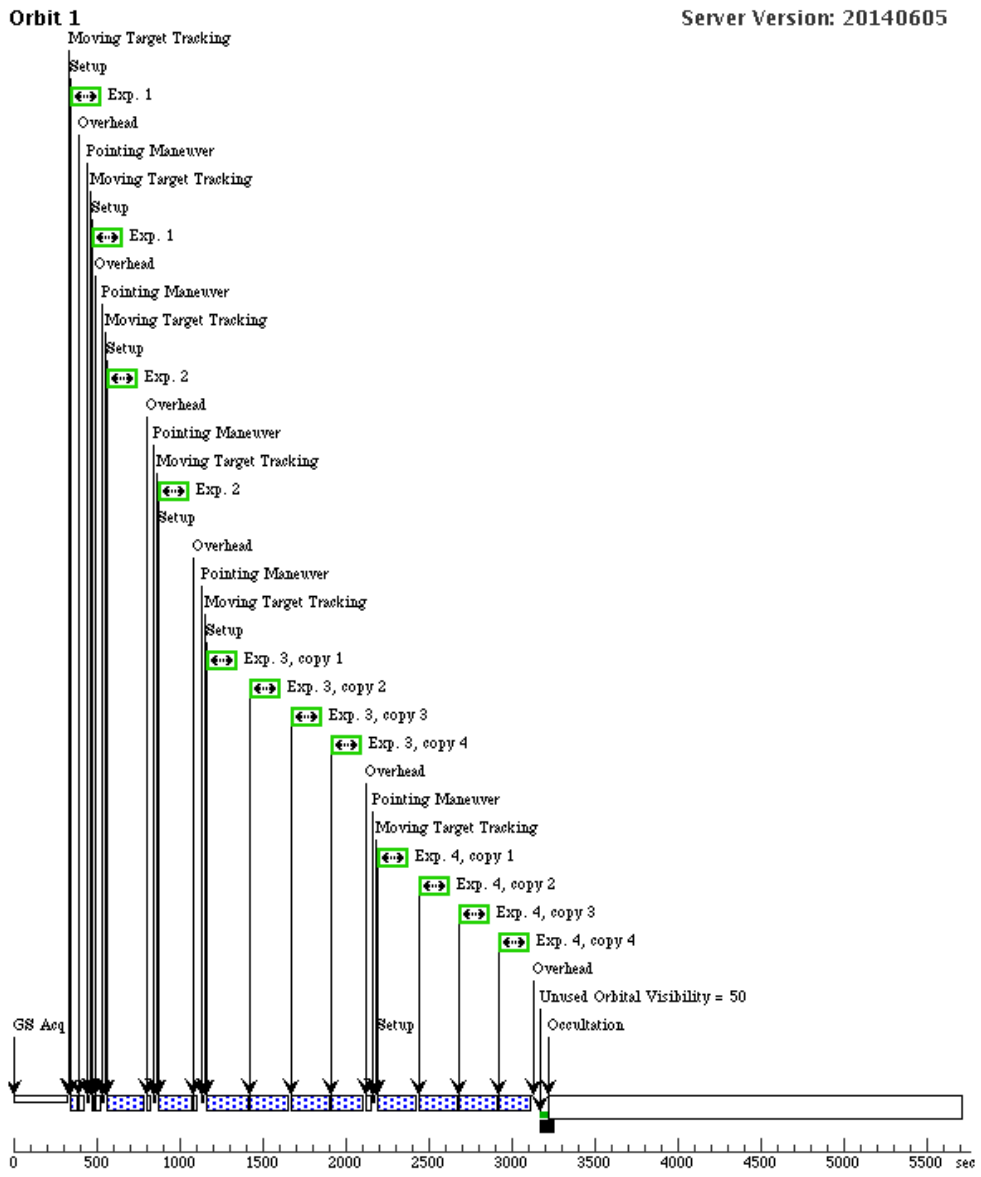
#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	CHARIKLORING	TYPE=ASTEROID,A=15.7542393762 0195,E=0.1715964458910988,I=23.41 166280741038,O=300.3798243316353 ,W=241.6005157950247,M=60.13086 140827895,EQUINOX=J2000,EPOCH =23-MAY- 2014:00:00:00,EpochTimeScale=TDB				EARTH

Proposal 13713 - Visit 02 - Observation of Chariklo's rings

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ring-broad-band	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F475X	CR-SPLIT=NO	POS TARG 3.0,0.	Pattern 1, Exps 1-1 in Visit 02 (1)	7 Secs (14 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
2	ring-UV	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F300X	CR-SPLIT=NO	POS TARG 3.0,0.	Pattern 1, Exps 2-2 in Visit 02 (1)	200 Secs (400 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
3	long-part 1	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 3.0,0.0		190 Secs X 4 (760 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***
4	long-part 2	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 3.14,0.14		190 Secs X 4 (760 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***

Orbit Structure



Proposal 13713 - Visit 03 - Observation of Chariklo's rings

Visit

Proposal 13713, Visit 03, implementation Wed Oct 08 01:10:42 GMT 2014

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 180D TO 180D FROM 01; AFTER 01 BY 30 D TO 70 D

Comments: We are searching for objects within 2 arcsec away the central body (Chariklo). The design of this visit is identical to visit 1 except for a 180 degree rotation needed to isolate the ring. The three visits provide two epoch of difference images that will contrain ring properties. The timing window is set to get confirmation of any new satellites at the earliest possible epoch consistent with the roll constraint.

The "ring-broad-band" and "ring-UV" avoid saturation for accurate photometry and colors. The POS-TARG value use for all exposures is set to keep the target away from the bad column in the sub-array. The 2 point dither "pattern 1" is chosen for cosmic ray rejection and to move the target relative to any blemishes in the image. The exposure times in these color observations are set by our SNR requirements without saturation on Chariklo and its rings.

"long-part 1" and "2" are longer exposures for looking for satellites. There is no dithering within these sets but there is a slight dither built in to the second part that mimics the two-point dither pattern while minimizing overhead from the dither operation. This pattern follows the successfull strategy used for Pluto during the search for faint satellites. The exposure times for these images are set to all be identical and to fill the orbit without excessive saturation from the central object.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	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)

Solar System Targets

#	Name	Level 1	Level 2	Level 3	Window	Ephem Center
(1)	CHARIKLORING	TYPE=ASTEROID,A=15.7542393762 0195,E=0.1715964458910988,I=23.41 166280741038,O=300.3798243316353 ,W=241.6005157950247,M=60.13086 140827895,EQUINOX=J2000,EPOCH =23-MAY- 2014:00:00:00,EpochTimeScale=TDB				EARTH

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	ring-broad-band	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F475X	CR-SPLIT=NO	POS TARG 3.0,0.	Pattern 1, Exps 1-1 in Visit 03 (1)	7 Secs (14 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
2	ring-UV	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F300X	CR-SPLIT=NO	POS TARG 3.0,0.	Pattern 1, Exps 2-2 in Visit 03 (1)	200 Secs (400 Secs) *[==>(Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
3	long-part 1	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 3.0,0.0		190 Secs X 4 (760 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***
4	long-part 2	(1) CHARIKLORING	WFC3/UVIS, ACCUM, UVIS2-C512C-SUB	F350LP	CR-SPLIT=NO	POS TARG 3.14,0.14		190 Secs X 4 (760 Secs) *[==>(Copy 1)]* *[==>(Copy 2)]* *[==>(Copy 3)]* *[==>(Copy 4)]*	***[1]***

Orbit Structure