15707 - Is the z=6.3 QSO PSOJ083+11 an accretion monster or gravitationally lensed?

Cycle: 26, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Knud Jahnke (PI) (ESA Member) (Contact)	**Max-Planck-Institut fur Astronomie, Heidelberg**	**jahnke@mpia-hd.mpg.de**
Irham Taufik Andika (CoI) (ESA Member)	Max-Planck-Institut fur Astronomie, Heidelberg	andika@mpia.de
Jan-Torge Schindler (CoI) (ESA Member)	Max Planck Institute for Astronomy	schindler@mpia.de
Dr. Masafusa Onoue (CoI) (ESA Member)	Max Planck Institute for Astronomy	onoue@mpia-hd.mpg.de
Eduardo Banados (CoI) (ESA Member)	Max-Planck-Institut fur Astronomie, Heidelberg	banados@mpia.de
Dr. Bram Venemans (CoI) (ESA Member)	Max-Planck-Institut fur Astronomie, Heidelberg	venemans@mpia-hd.mpg.de
Dr. Roberto Decarli (CoI) (ESA Member)	INAF,Osservatorio di Astrofisica e Scienza dello Spaz io di B	roberto.decarli@inaf.it
Dr. Emanuele Paolo Farina (CoI) (ESA Member)	University of California - Santa Barbara	emanuele.paolo.farina@gmail.com
Dr. Thomas Cooper (CoI) (AdminUSPI)	Carnegie Institution of Washington	tcooper08.12@gmail.com
Dr. Chiara Giulia Mazzucchelli (CoI) (ESA Member)	European Southern Observatory - Chile	chiara.mazzucchelli@eso.org

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) PSOJ083+11	WFC3/IR	1	04-Apr-2019 13:00:15.0	yes
02	(1) PSOJ083+11	WFC3/IR	1	04-Apr-2019 13:00:15.0	yes
03	(1) PSOJ083+11	ACS/WFC	2	04-Apr-2019 13:00:16.0	yes

4 Total Orbits Used

ABSTRACT

We want to use HST to decide whether the newly discovered z=6.3 QSO PSOJ083+11 (a) either has the fastest growing supermassive black hole of any high-z QSO, or (b) is the second known gravitationally lensed QSO at z>5. PSOJ083+11 was discovered by us a month ago and follow-up spectroscopy showed remarkable features. Taken at face value, its calibrated black hole mass would only lie around 7x10^7 M_sun, but with the extremely high specific accretion rate L/L_Edd=14. This would be the highest accretion rate of any high-redshift QSO and, if extrapolated back, would only require ~100 Myrs of growth to the current mass. If this were a standard early mode of black hole growth, the still lingering "seed problem" of limited time in the early Universe would disappear.

However, one very interesting caveat exists: the flux and apparent accretion rate of PSOJ083+11 could be boosted by gravitational lensing. While there is no obvious nearby companion in ground-based images, the ground-based seeing prohibits detecting the vast majority of potential lens configurations. Only HST has the spatial resolution to test for potential lensing in this QSO, and decide whether PSOJ083+11 can subsequently be used for either studying ultra-fast early black hole growth, or, if shown to be lensed, be a prime source for studies of the IGM and the QSO host galaxy through its spatial and flux magnification.

We want to test the lensing hypothesis by both searching for multiple QSO images in WFC3/IR J-band images, as well as directly search for an intervening galaxy with an ACS narrow band in the QSOs Gunn-Peterson absorption trough, where the QSO light is minimal.

OBSERVING DESCRIPTION

We want to use two diagnostics in this programme, each using 2 orbits.

The target is a newly discovered z=6.3 QSO with seemingly extremely high luminosity for its black hole mass. One possible explanation is a "boosting" of its flux by gravitational lensing. In this case, an intervening galaxy, most likely between z~0.5 and z=2 would be near the line-of-sight from us to the QSO, creating multiple images of the QSO. These would each be magnified in size, but while even at HST resolution the images would remain point-like, the flux in each image could be increased by a factor 2-50.

We want to make 2 independent tests on whether this QSO is gravitationally lensed or not:

(1) Use WFC3/IR images to search for 2 or more point-like images of the QSO where we only see a single point source from the ground. For this purpose we want to take images in F125W, where we will find QSO continuum longward of Lyman-alpha. The host galaxy of the QSO will be too faint to be visible, only the QSO nucleus will provide flux. Since the separation of the potential multiple images depends on the mass and position of the intervening galaxy, we do not have a prediction for these separations, only that they would be less than what could be made out from the ground in ~1" seeing conditions, so <~0.5".

We want to compare these images with point source references (=stars) from the same field and from the archive, to see in the case of no obvious double/quadruple QSO images whether we also rule out significant elongations in some direction indicating an unresolved double nucleus.

For the same general goal we planned the split into two visits and to take images at a slight angle (10-20degrees) with respect to the first visit of F125W imaging. With this rotation we can apply difference imaging, by subtracting one image from the other. Any marginally resolved double/quadrupel structure should leave characteristic residuals in such a difference image. NOTE: we were only able to specify relative angles between 1st and 2nd visit in one rotation direction. We chose "between +10 and +20 degrees". However, it is equally fine to use -10 to -20 degrees offset, but this couldn't be added in the APT field. We assume this could be implemented manually.

We define a line pattern to dither wide enough to not land on potential persistence flux from our (point-like or near point-like) target, but also avoid the persistence from a brighter neighbor to the N-N-E and a fainter one to the S-E. The "90 degrees" angle is supposed to shift our target only on an East-West line.

(2) A two-orbit image of the potential lensing galaxy using an ACS/WFC tunable narrowband ramp filter. The target wavelength (8660A) lies in the redshifted absorption through (Gunn-Peterson-trough) shortward of Lyman-alpha for this QSO. At this wavelength most emission by the QSO itself is absorbed by neutral Hydrogen in the intergalactic medium. This means, the emission of any intervening, lower-z lensing galaxy could be visible with minimal disturbance by the background QSO. Any astrometric offset between a light "blob" at this position and the QSO position as determined with WFC3/IR can be immediately interpreted as this blob being a lensing galaxy. In this case the position and (narrow-band) luminosity can be used to contrain the potential flux boosting, and inform follow-up to derive its actual redshift.

So for this purpose we need to place our target in a way that its position on the ramp filter corresponds to 8660A. We assume that this is what happens automatically since we defined the ramp filter and aperture to be used, and wavelength of interest. We need to dither to remove any dead/hot

pixels and CR hits, but looking at the statistics we do not need more than 4 images from these 2 orbits. NOTE: could you please check how much the chosen dither box will change the central wavelength? We have some leeway in the central wavelength and it does not have to be fully identical in the 4 images, but would like to avoid large shifts. Despite extended searches, we could not find the appropriate information of this in the Phase II Proposal Instructions or the Instrument Handbook.

Visit

Proposal 15707, J-band visit 1 (01) Thu Apr 04 17:00:17 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Comments: Goal is to measure potential multiplicity of QSO images. If multiple then this is likely gravitationally lensed, if single, it is not lensed.

Simple imaging in F125W split into 4 exposures to avoid saturation. Line pattern for 4 exposures to get background correction and avoid nearby companions to N-NE and S-E.

Orientation of first J-band visit (this visit) is arbitrary. Orientation of second visit (J-band visit 2) should have orientation within 10-20degreesfrom this visit.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=BACKGROUND	Pattern Orientation=90.0		
	Number Of Points=4	Angle Between Sides=		
	Point Spacing=7.0	Center Pattern=true		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PSOJ083+11	RA: 05 35 20.8960 (83.8370667d)	Proper Motion RA: 0 mas/yr	V=(?)	Reference Frame: ICRS
		Dec: +11 50 53.65 (11.84824d)	Proper Motion Dec: 0 mas/yr	J_Johnson(Vega)=20.1	
		Equinox: J2000			

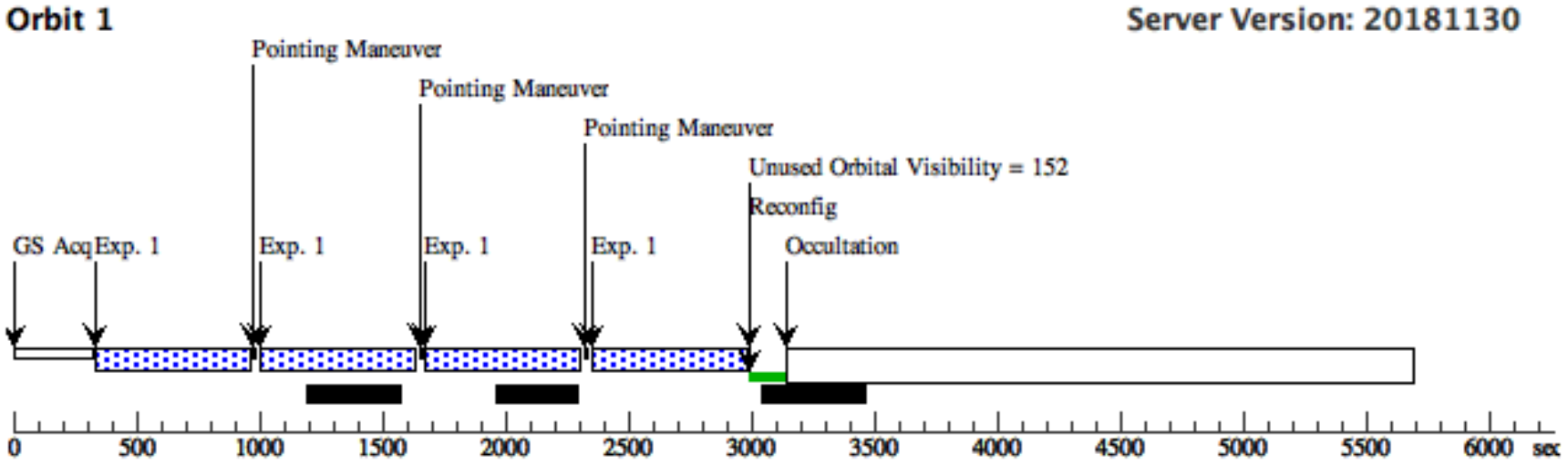
Comments: Target is a QSO with a brighter neighbor at ~3" distance.
Category=GALAXY
Description=[GRAVITATIONAL LENS, QSO]

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Generic J-band for J083 (WFC3IR.im.1334609)	(1) PSOJ083+11	WFC3/IR, MULTIACCUM, IR	F125W	SAMP-SEQ=SPARS50; NSAMP=13		Pattern 1, Exps 1-1 in J-band visit 1 (01) (1)	602.937703 Secs (2411.751 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	

Comments: We want to detect multiplicity in a bright QSO nucleus, saturating only after ~1000s. Our exposure with SPARS50 and NSAMP=14 should go to less than 70% of saturation in the peak.

Orbit Structure



Visit

Proposal 15707, J-band visit 2 (02) Thu Apr 04 17:00:17 GMT 2019

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: ORIENT 10D TO 20D FROM 01

Comments: Goal is to measure potential multiplicity of QSO images. If multiple then this is likely gravitationally lensed, if single, it is not lensed.

Simple imaging in F125W split into 4 exposures to avoid saturation. Line pattern for 4 exposures to get background correction and avoid nearby companions to N-NE and S-E.

Orientation of first J-band visit (J-band visit 1) is arbitrary. Orientation of second visit (this visit) should have orientation within (plus or minus!) 10-20degrees from first visit.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=LINE	Coordinate Frame=CELESTIAL		(1)
	Purpose=BACKGROUND	Pattern Orientation=90.0		
	Number Of Points=4	Angle Between Sides=		
	Point Spacing=7.0	Center Pattern=true		
	Line Spacing=			

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PSOJ083+11	RA: 05 35 20.8960 (83.8370667d)	Proper Motion RA: 0 mas/yr	V=(?)	Reference Frame: ICRS
		Dec: +11 50 53.65 (11.84824d)	Proper Motion Dec: 0 mas/yr	J_Johnson(Vega)=20.1	
		Equinox: J2000			

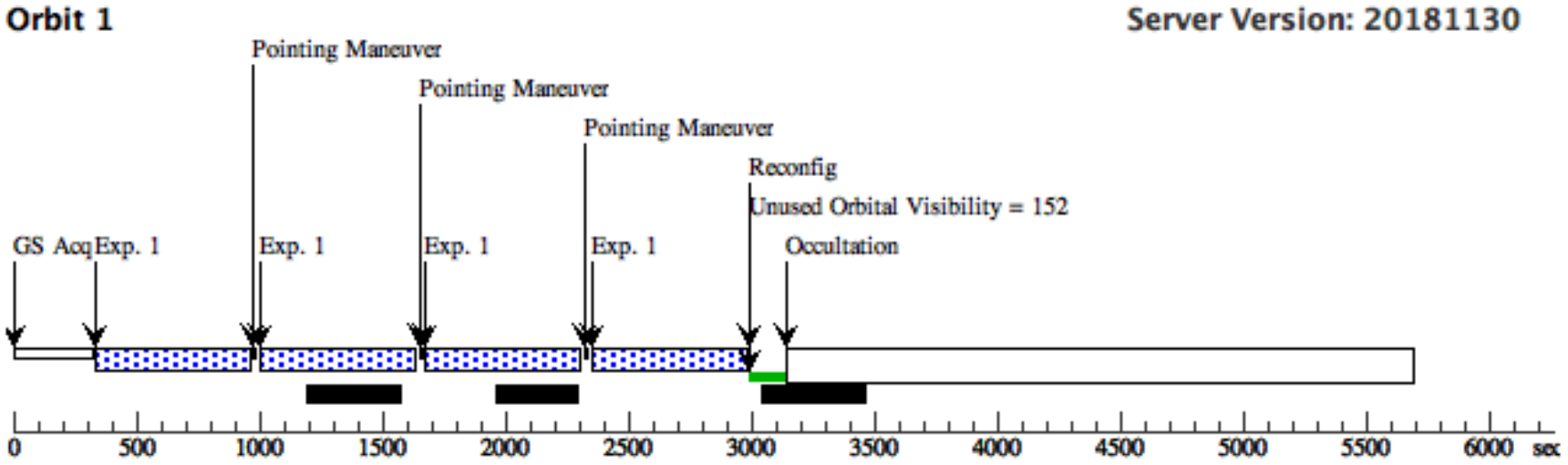
Comments: Target is a QSO with a brighter neighbor at ~3" distance.
Category=GALAXY
Description=[GRAVITATIONAL LENS, QSO]

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	Generic J-band for J083 (WFC3IR.im.1334609)	(1) PSOJ083+11	WFC3/IR, MULTIACCUM, IR	F125W	SAMP-SEQ=SPARS50; NSAMP=13		Pattern 1, Exps 1-1 in J-band visit 2 (02) (1)	602.937703 Secs (2411.751 Secs)	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	

Comments: We want to detect multiplicity in a bright QSO nucleus, saturating only after ~1000s. Our exposure with SPARS50 and NSAMP=14 should go to less than 70% of saturation in the peak.

Orbit Structure



Visit

Proposal 15707, ACS ramp narrow filter visit 1 (03) Thu Apr 04 17:00:17 GMT 2019

Diagnostic Status: Warning

Scientific Instruments: ACS/WFC

Special Requirements: (none)

Comments: We want to observe in an absorption trough of a z=6.3 QSO to see a potential lensing galaxy.

We want to use a narrow band filter in this trough, defined by the ramp filter FR853N, with the target moved to the right position for the filter to be centered on XXXX Angstrom observed frame.

Diagnostics

(Exposure 1 (Pattern 4, Exps 1-1 in ACS ramp narrow filter visit 1 (03))) Warning (Form): POS TARG & PATTERN should be used carefully with ACS ramp filters as central wavelengths & transmission efficiencies vary within the apertures.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(4)	Pattern Type=ACS-WFC-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.262 Line Spacing=0.192	Coordinate Frame=POS-TARG Pattern Orientation=18.39 Angle Between Sides=68.14 Center Pattern=true		(1)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PSOJ083+11	RA: 05 35 20.8960 (83.8370667d) Dec: +11 50 53.65 (11.84824d) Equinox: J2000	Proper Motion RA: 0 mas/yr Proper Motion Dec: 0 mas/yr	V=(?) J_Johnson(Vega)=20.1	Reference Frame: ICRS

Comments: Target is a QSO with a brighter neighbor at ~3" distance.
Category=GALAXY
Description=[GRAVITATIONAL LENS, QSO]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) PSOJ083+11	ACS/WFC, ACCUM, WFC1-IRAMPQ	FR853N 8660 A	CR-SPLIT=NO		Pattern 4, Exps 1-1 in ACS ramp narrow filter visit 1 (03) (4)	1200 Secs (4984 Secs)	
								[==>1218.0 Secs (Pattern 1)] *[==>1218.0 Secs (Pattern 2)]*	***[1]***
								[==>1274.0 Secs (Pattern 3)] *[==>1274.0 Secs (Pattern 4)]*	***[2]***

Orbit Structure