17304 - A Systematic Survey of Close Dual and Lensed SMBHs at Cosmic Noon

Cycle: 30, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Prof. Xin Liu (PI) (Contact)	**University of Illinois at Urbana - Champaign**

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) SDSSJ0956+6900	STIS/CCD	1	07-Jun-2024 15:02:28.0	yes
02	(2) SDSSJ1002+4449	STIS/CCD	1	07-Jun-2024 15:02:29.0	yes
03	(3) SDSSJ1008+0351	WFC3/IR	1	07-Jun-2024 15:02:30.0	yes
04	(4) SDSSJ1238+0105	WFC3/IR	1	07-Jun-2024 15:02:32.0	yes

4 Total Orbits Used

ABSTRACT

STIS G430L slit spectroscopy and WFC3 F160W imaging are proposed to systematically confirm close (<5 kpc) dual and strong gravitationally lensed quasars at Cosmic Noon (1<z<3). The sample probes a new regime at higher redshifts, higher luminosities, and smaller separations than previous work. This poorly explored regime is crucial for understanding the impact of mergers in triggering SMBH accretion at Cosmic Noon - the peak quasar epoch. The targets are selected from Gaia using two new techniques. Targets have been carefully chosen to minimize interlopers from star-quasar superpositions. Previous observations have uncovered ~0.3"-0.7" double/triple cores in each target, suggesting dual/triple or lensed quasars, but the existing data are insufficient for determining their physical origins. The proposed new observations will unambiguously establish the targets as 1<z<3 sub-arcsecond dual/triple or lensed quasars. STIS will detect spatially resolved spectra from each nucleus and measure SMBH and accretion properties (mass, mass ratio, and Eddington ratio) to put them into their cosmological context. WFC3 imaging will detect the much fainter

extended host galaxy mergers against the bright quasars and possibly low surface brightness tidal features indicative of ongoing mergers in dual quasars, or foreground lenses in lensed quasars. The results will elucidate the 1<z<3 sub-arcsec dual/lensed quasar population statistics. It will provide empirical constraints on the merger rate of 1<z<3 SMBHs and inform the prospects of binary SMBHs as targets for multi-messenger astronomy. Alternatively, discovery of small-scale lensed quasars would be equally interesting in its own right.

OBSERVING DESCRIPTION

This program will conduct WFC3/IR F160W imaging (for 2 targets that have existing spatially resolved spectroscopy but lack high-resolution deep IR imaging) and STIS/G430L slit spectroscopy (for 2 targets that have existing high-resolution deep IR imaging but lack spatially resolved spectroscopy) for a total sample of 4 candidate kpc-scale dual/lensed quasars at z~1--3. The targets have close double cores with separations of ~0.3"--0.7". The targets are a subset of a complete sample of high-fidelity double quasars at z>1 selected using two new techniques that have been developed recently (i.e., "varstrometry" and Gaia Multi Peak). Deep HST IR F160W imaging will detect the extended host galaxy mergers and low-surface-brightness tidal features (indicative of ongoing mergers) or foreground lenses to umambiguously distinguish between dual and lensed quasars. STIS slit spectroscopy will detect spatially resolved spectra simultaneously covering both nuclei.

In dual quasars, the unresolved quasars will be carefully modeled (by PSFs) and subtracted in order to robustly reveal the (much fainter) extended host galaxies underlying each quasar. Furthermore, after carefully subtracting both the quasars (PSFs) and the host galaxies (using Sersic models), we may discover low surface brightntess tidal features as direct evidence for mergers. Alternatively, in lensed quasars, the unresolved lensed quasar images will be carefully modeled (using PSFs) and subtracted in order to either detect or put stringnet upper limits on the foreground lens galaxy. Using the structure decomposition constraints (on both the lensed images and the lens), we will perform strong lensing mass modeling tests in order to quantitatively assess the strong gravitational lensing scenario. The results will reveal bona-fide high-redshift kpc-scale dual quasars that are still largely illusive (but are predicted to be abundant by theory).

For the WFC3 IR F160W imaging, we adopt the 256x256 subarray (30"x30" FOV, corresponding to ~250kpcx250kpc at z=2, more than enough to cover the double quasars and host galaxies). We adopt SPARS10 (NSAMP=15) to increase the dynamic range and account for potential saturation of bright cores, and the 4-step BOX dither (similar to the default WFC3-IR-DITHER-BOX-MIN but with increased spacing to meet the >10 pixel requirement to avoid persistence effects) for cosmic-ray and bad-pixel rejection, to better sample the PSF for optimal effective resolution. Since our primary goal is to detect the lens galaxy (or the lack thereof) rather than to accurately measure host galaxy morphology, this dither pattern is sufficient - nor do we require a dedicated PSF observation; we will use field stars and/or recent archival data to build an empirical PSF template. The

IR depth assuming 412s on-source exposure is H~24 AB mag arcsec^-2 (3\sigma), sufficient to detect double cores and rule out lensing.

For the STIS slit spectroscopy, we use the 52x0.2" slit and the G430L aperture. The slit will be placed across both cores to obtain the spectrum for both components. The separation between the two cores is ~0.3"--0.7", and we will use the point-source mode for acquisition. The conversion between the PA of the two cores and the ORIENT parameter is: ORIENT=PA+45.35 or ORIENT=PA+225.35 according to Table 11.2 of the STIS Instrument Handbook.

Visit

Proposal 17304, J0956_STIS_G430L (01), implementation Fri Jun 07 19:02:32 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/CCD

Special Requirements: ORIENT 288.15D TO 288.15 D; ORIENT 108.15D TO 108.15 D

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=90.0		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=1.0	Center Pattern=false		
	Line Spacing=			

Fixed Targets

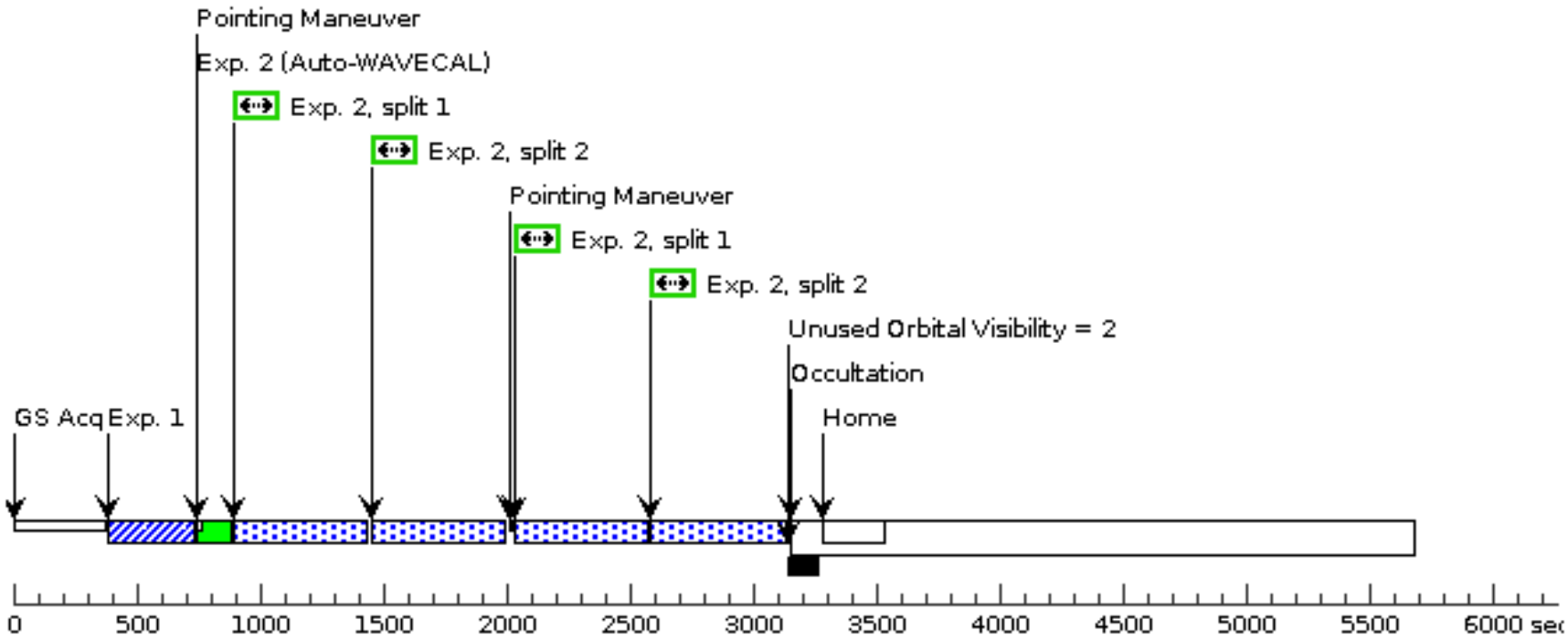
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	SDSSJ0956+6900	RA: 09 56 36.4500 (149.1518750d)	Redshift: 1.975	V=(?)	Reference Frame: ICRS
		Dec: +69 00 28.10 (69.00781d)		r=18.01,	
		Equinox: J2000		z=17.59	

Comments:
Category=GALAXY
Description=[QUASAR]
Extended=NO

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.1845207)	(1) SDSSJ0956+6900	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			30 Secs (30 Secs)	
								[==>]	***[1]***
2		(1) SDSSJ0956+6900	STIS/CCD, ACCUM, 52X0.2E1	G430L 4300 A	CR-SPLIT=2		Pattern 2, Exps 2-2 in J0956_STIS_G430L (01) (2)	1200 Secs (2044 Secs)	
								[==>511.0 Secs (Pattern 1, Split 1)]	***[1]***
								[==>511.0 Secs (Pattern 1, Split 2)]	
								[==>511.0 Secs (Pattern 2, Split 1)]	
								[==>511.0 Secs (Pattern 2, Split 2)]	

Orbit Structure



Visit

Proposal 17304, J1002_STIS_G430L (02), completed Fri Jun 07 19:02:33 GMT 2024

Diagnostic Status: Warning

Scientific Instruments: STIS/CCD

Special Requirements: ORIENT 151.05D TO 151.55 D; ORIENT 331.05D TO 331.55 D

Diagnostics

(J1002_STIS_G430L (02)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	Pattern Type=STIS-ALONG-SLIT	Coordinate Frame=POS-TARG		(2)
	Purpose=DITHER	Pattern Orientation=90.0		
	Number Of Points=2	Angle Between Sides=		
	Point Spacing=1.0	Center Pattern=false		
	Line Spacing=			

Fixed Targets

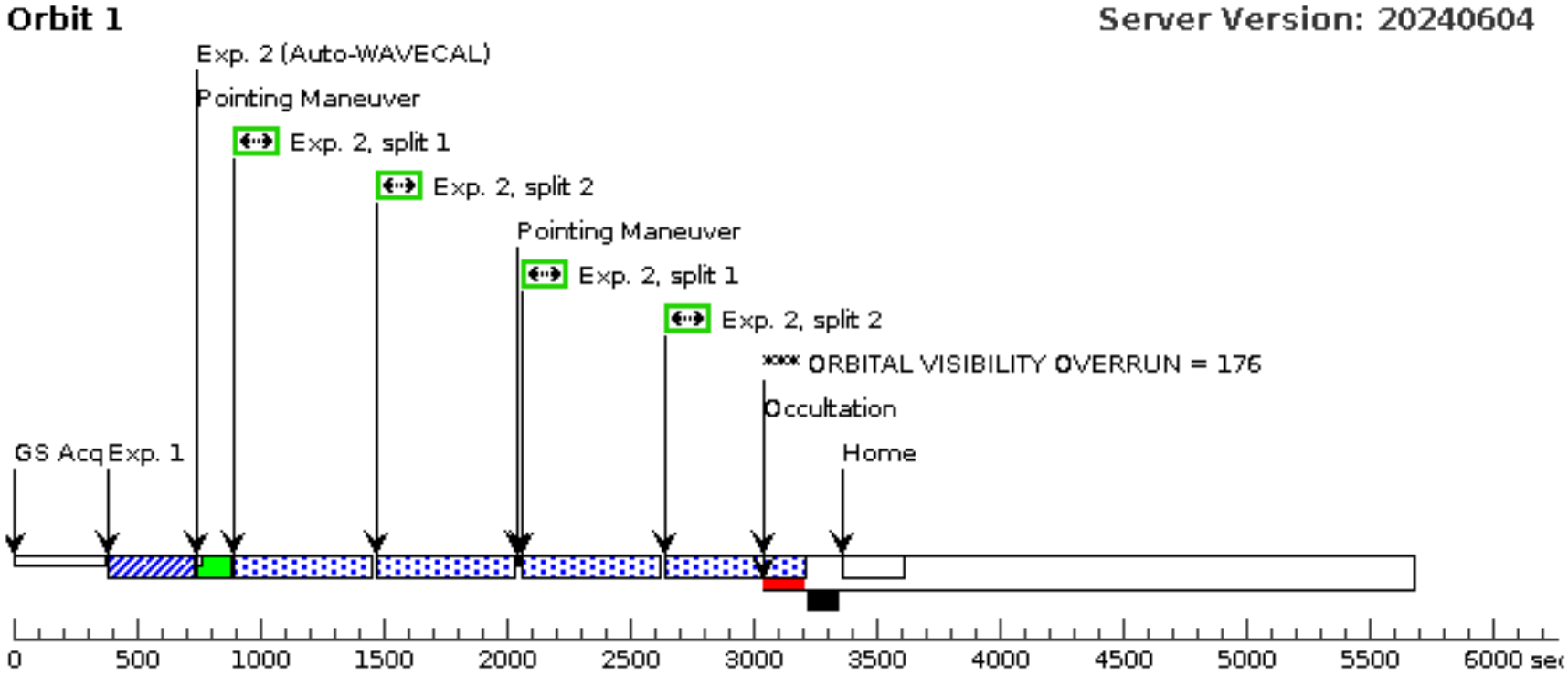
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	SDSSJ1002+4449	RA: 10 02 29.4500 (150.6227083d)	Redshift: 2.055	V=(?)	Reference Frame: ICRS
		Dec: +44 49 42.84 (44.82857d)		r=18.27,	
		Equinox: J2000		z=17.99	

Comments:
Category=GALAXY
Description=[QUASAR]
Extended=NO

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.1845208)	(2) SDSSJ1002+4449	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT			30 Secs (30 Secs)	
								[==>]	***[1]***
2		(2) SDSSJ1002+4449	STIS/CCD, ACCUM, 52X0.2E1	G430L 4300 A	CR-SPLIT=2		Pattern 2, Exps 2-2 in J1002_STIS_G430L (02) (2)	1200 Secs (2120 Secs)	
								[==>530.0 Secs (Pattern 1, Split 1)]	***[1]***
								[==>530.0 Secs (Pattern 1, Split 2)]	
								[==>530.0 Secs (Pattern 2, Split 1)]	
								[==>530.0 Secs (Pattern 2, Split 2)]	

Orbit Structure



Visit

Proposal 17304, J1008_IR_F160W (03), completed Fri Jun 07 19:02:33 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=1.365 Line Spacing=0.975	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
(3)	SDSSJ1008+0351	RA: 10 08 59.5500 (152.2481250d) Dec: +03 51 4.40 (3.85122d) Equinox: J2000	Redshift: 1.746	V=(?) r=19.41, z=18.79	Reference Frame: ICRS

Comments: New replacement target.

The old target (SDSSJ1608+2716) has a duplicate WFC3 IR F160W image (recently observed after proposal submission). The new target has existing spatially resolved spectroscopy, but it still needs WFC3 IR F160W imaging to achieve the science goals.

Please advise if TTRB is needed.
Category=GALAXY
Description=[QUASAR]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(3) SDSSJ1008+0351	WFC3/IR, MULTIACCUM, IRSUB256	F160W	SAMP-SEQ=SPARS10; NSAMP=15		Pattern 1, Exps 1-1 in J1008_IR_F160W (03) (1)	103.128633 Secs X 5 (2062.573 Secs)	
								[==>(Pattern 1, Copy 1)]	*[1]*
								[==>(Pattern 1, Copy 2)]	
								[==>(Pattern 1, Copy 3)]	
								[==>(Pattern 1, Copy 4)]	
								[==>(Pattern 1, Copy 5)]	
								[==>(Pattern 2, Copy 1)]	
								[==>(Pattern 2, Copy 2)]	
								[==>(Pattern 2, Copy 3)]	
								[==>(Pattern 2, Copy 4)]	
								[==>(Pattern 2, Copy 5)]	
								[==>(Pattern 3, Copy 1)]	
								[==>(Pattern 3, Copy 2)]	
								[==>(Pattern 3, Copy 3)]	
								[==>(Pattern 3, Copy 4)]	
								[==>(Pattern 3, Copy 5)]	
								[==>(Pattern 4, Copy 1)]	
								[==>(Pattern 4, Copy 2)]	
								[==>(Pattern 4, Copy 3)]	
								[==>(Pattern 4, Copy 4)]	
								[==>(Pattern 4, Copy 5)]	

Orbit Structure

Visit

Proposal 17304, J1238_IR_F160W (04), completed Fri Jun 07 19:02:33 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=1.365 Line Spacing=0.975	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
(4)	SDSSJ1238+0105	RA: 12 38 21.6600 (189.5902500d) Dec: +01 05 18.60 (1.08850d) Equinox: J2000	Redshift: 3.159	V=(?) r=18.82, z=18.55	Reference Frame: ICRS

Comments: New replacement target.

The old target (SDSSJ1625+4309) has a duplicate STIS spectrum (recently observed after proposal submission). The new target has existing spatially resolved spectroscopy, but it still needs WFC3 IR F160W imaging to achieve the science goals.

Please advise if TTRB is needed.
Category=GALAXY
Description=[QUASAR]
Extended=NO

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(4) SDSSJ1238+0105	WFC3/IR, MULTIACCUM, IRSUB256	F160W	SAMP-SEQ=SPARS10; NSAMP=15		Pattern 1, Exps 1-1 in J1238_IR_F160W (04) (1)	103.128633 Secs X 5 (2062.573 Secs)	
								[==>(Pattern 1, Copy 1)] *[==>(Pattern 1, Copy 2)]* *[==>(Pattern 1, Copy 3)]* *[==>(Pattern 1, Copy 4)]* *[==>(Pattern 1, Copy 5)]* *[==>(Pattern 2, Copy 1)]* *[==>(Pattern 2, Copy 2)]* *[==>(Pattern 2, Copy 3)]* *[==>(Pattern 2, Copy 4)]* *[==>(Pattern 2, Copy 5)]* *[==>(Pattern 3, Copy 1)]* *[==>(Pattern 3, Copy 2)]* *[==>(Pattern 3, Copy 3)]* *[==>(Pattern 3, Copy 4)]* *[==>(Pattern 3, Copy 5)]* *[==>(Pattern 4, Copy 1)]* *[==>(Pattern 4, Copy 2)]* *[==>(Pattern 4, Copy 3)]* *[==>(Pattern 4, Copy 4)]* *[==>(Pattern 4, Copy 5)]*	***[1]***

Orbit Structure