16739 - First measurement of the super-massive black hole mass using strong gravitational lensing

Cycle: 29, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

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Mr. Kirill Grishin (CoI)	Lomonosov Moscow State University	grishin@voxastro.org

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) NGC524-OFFNUC (2) NGC524-CENTER	STIS/CCD STIS/NUV-MAMA	2	30-Jul-2021 14:05:49.0	yes
02	(1) NGC524-OFFNUC (2) NGC524-CENTER	STIS/CCD STIS/NUV-MAMA	2	30-Jul-2021 14:05:50.0	yes

4 Total Orbits Used

ABSTRACT

We have serendipitously discovered a strong gravitational lens candidate by inspecting archival HST images collected with the WFC3/UVIS in the near-UV F225W photometric band and re-confirmed it using the archival ACS/HRC F330W image. It appears as a 120 deg arc with a radius of 0.8"

centered 0.08" S of the nucleus of the giant early type galaxy NGC524 (d=22Mpc) that, if confirmed, makes NGC524 the most nearby strong gravitational lens. NGC524 has a supermassive black hole (SMBH) of 800 million MSun measured from stellar kinematics. However, VLBI radio observations show a point source offset by 0.1" from the photometric center of NGC524 and its position almost exactly matches the center of the UV arc. NGC524 is the only galaxy one where the contributions of stars and a SMBH within the Einstein radius are comparable and can be separated (dark matter contribution is negligible). Unfortunately, the optical surface brightness of V=16 mag/sq.arcsec prevent the spectroscopic redshift measurement of the lensed source. In near-UV the source has 300 higher contrast than in the optical because of the old stellar population in NGC524. We propose to obtain STIS near-UV spectra of the lensed source covering the wavelengths from 1650 to 3200A and determine its redshift. This will allow us to: (a) confirm or reject the Einstein ring hypothesis; (b) if confirmed this will be the first measurement of the SMBH mass done with a principally new technique; (c) if rejected and the source turns to be a structural component of NGC524, it will become a rare example of a star forming star cluster or a tiny dwarf galaxy being tidally disrupted while approaching the SMBH sphere of influence.

OBSERVING DESCRIPTION

UV spectroscopic capabilities of the Hubble Space Telescope are absolutely crucial for the success of our project. Because of the very low contrast of the arc on top of a very bright nuclear region of NGC 524 we cannot perform our project in the optical domain. The only other instrument having spectroscopic capabilities in the Near-UV is SWIFT, where a UV grism is available. However, the spectral resolution delivered in this mode is insufficient to detect absroption lines from stars or narrow emission lines from star formation, and the collecting area of SWIFT in the Near-UV is over an order of magnitude smaller than that of the HST, making our project unfeasible with SWIFT.

We propose to use STIS in the long-slit mode with the 52x0.5 arcsec slit in the NUV/MAMA setup with the G230L grating. The slit will be oriented in the North--South direction with the 10 deg tolerance on orientation centered 0.7 arcsec West of the NGC 524 nucleus. Using this strategy, we will be able to fit the whole arc into the slit and then integrate the light. Beyond r=0.2 arcsec from the nucleus, the galaxy has very low surface brightness in the UV domain because of its old stellar population.

We have analyzed the archival WFC3/UVIS F225W image and estimated the total AB magnitude of the arc F225W=21.2 mag. In the worst case scenario, if the lensed source does not exhibit any emission lines, we need a minimal signal-to-noise ratio of about 6 per resolution element in order to perform the redshift determination from strong UV absorption lines. Depending on the redshift of the source, we will see MgII (280nm), CIII (191nm), CIV (155nm), SiII (121nm, 131nm, 181nm), or Ly-a (122nm). If there are emission lines which is very likely in a blue star-forming galaxy, the signal-to-noise ratio in the lines will be substantially higher (30 or more depending on the fraction of the flux contained in them) for the same

exposure time.

We used the STIS exposure time calculator using a StarBurst galaxy template and found that we need 4 orbits corresponding to 9,400 sec of the total science integration time (2350 sec per orbit) in order to reach the desired signal-to-noise value of 10 at 250 nm.

We propose to use STIS rather than COS because it provides the entire wavelength coverage that we need in a single setup, and also because of the lower spectral resolution (which is still sufficient for our purposes) we will get substantially better signal-to-noise ratio compared to COS. Since the broad near-UV wavelength is important for us, we need the G230L grating. The objective prism does not provide sufficient spectral resolution for our purposes. NUV/MAMA setup is better suited for our project, because (a) the NUV/CCD setup has much lower sensitivity at shorter wavelengths; (b) the NUV/CCD setup has scattered light issues for red sources, and the NGC 524 is very red.

Visit

Proposal 16739, Visit 01 Fri Jul 30 18:05:51 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/NUV-MAMA, STIS/CCD

Special Requirements: ORIENT 44D TO 49 D

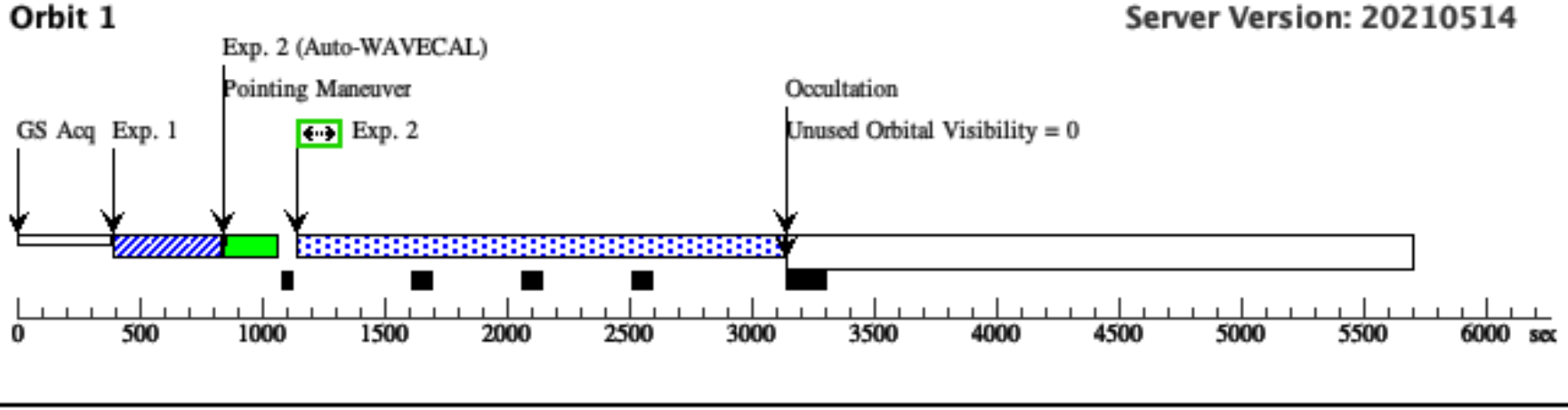
Fixed Targets

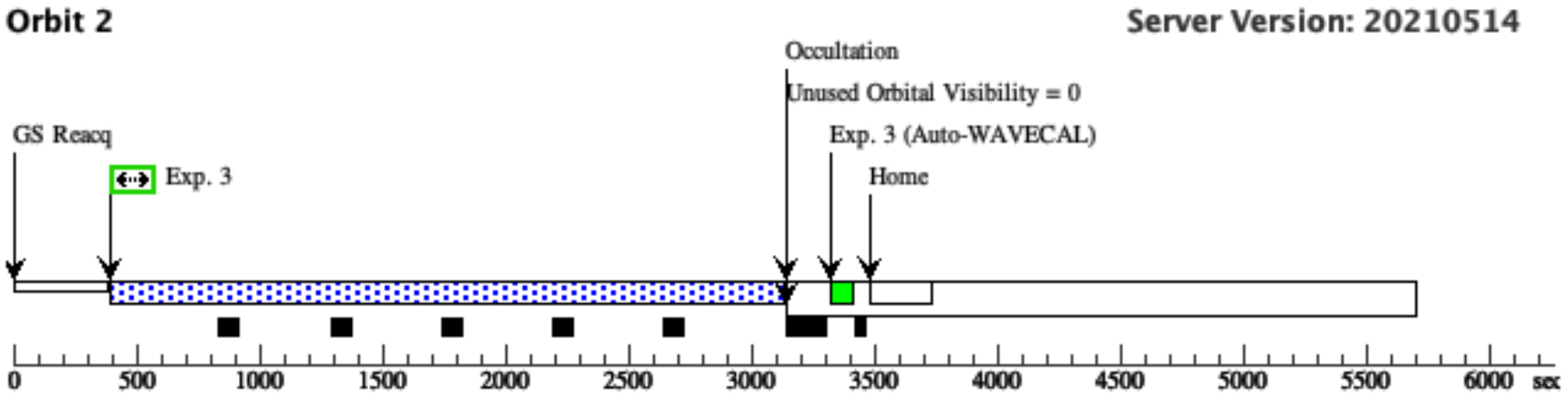
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	NGC524-OFFNUC	RA: 01 24 47.6900 (21.1987083d) Dec: +09 32 20.31 (9.53898d) Equinox: J2000		V=16+/-0.05 21.5 (AB F225W)	Reference Frame: ICRS
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=GALAXY* *Description=[EINSTEIN RING]* *Extended=YES*					
(2)	NGC524-CENTER	RA: 01 24 47.7452 (21.1989383d) Dec: +09 32 20.33 (9.53898d) Equinox: J2000		V=11.5	Reference Frame: ICRS
Comments: *Category=GALAXY* *Description=[NUCLEUS]* *Extended=YES*					

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(1528616)	(2) NGC524-CENTER	STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=DIFFUSE; DIFFUSE-CENTER=FLUX-CENTROID; CHECKBOX=21			30 Secs (30 Secs) *[==>]*	***[1]***
2	(1530041)	(1) NGC524-OFFNUC	STIS/NUV-MAMA, TIME-TAG, 52X0.5	G230L 2376 A	BUFFER-TIME=450			1975 Secs (1953 Secs) *[==>1953.0 Secs]*	***[1]***
3	(1530041)	(1) NGC524-OFFNUC	STIS/NUV-MAMA, TIME-TAG, 52X0.5	G230L 2376 A	BUFFER-TIME=450			2000 Secs (2725 Secs) *[==>2725.0 Secs]*	***[2]***

Orbit Structure





Visit

Proposal 16739, Visit 02 Fri Jul 30 18:05:51 GMT 2021

Diagnostic Status: No Diagnostics

Scientific Instruments: STIS/NUV-MAMA, STIS/CCD

Special Requirements: ORIENT 44D TO 49 D

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
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Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=GALAXY* *Description=[EINSTEIN RING]* *Extended=YES*					
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2	(1530041)	(1) NGC524-OFFNUC	STIS/NUV-MAMA, TIME-TAG, 52X0.5	G230L 2376 A	BUFFER-TIME=450			1975 Secs (1953 Secs) *[==>1953.0 Secs]*	*[1]*
3	(1530041)	(1) NGC524-OFFNUC	STIS/NUV-MAMA, TIME-TAG, 52X0.5	G230L 2376 A	BUFFER-TIME=450			2000 Secs (2725 Secs) *[==>2725.0 Secs]*	*[2]*

Orbit Structure