17602 - Understanding the Rapid Evolution in the Light Curve of the White Dwarf Pulsar AR Scorpii

Cycle: 31, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
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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) V-AR-SCO	COS/FUV COS/NUV	5	29-Jul-2024 16:01:04.0	yes

5 Total Orbits Used

ABSTRACT

The optical light curve of AR Scorpii has recently been found to be evolving at a rapid pace. AR Sco is the nearest and brightest white dwarf pulsar -- a binary system where synchrotron emission is powered by the spin-down of its magnetic degenerate primary. The white dwarf rotates every 1.95 minutes and generates two synchrotron pulses per spin, one from each of its magnetic poles. New observations in 2023 found that these two pulses were nearly equal in amplitude, while in 2015 the secondary pulse was half the strength of the primary. This rapid evolution has been explained as precession of the white dwarf spin axis caused by an obliquity to the binary orbital plane. However, the mechanism that accelerates the relativistic

electrons is uncertain, so other physical processes could be driving the evolution. We propose COS spectroscopy of this dynamic system to test for differences in the evolution between the far-UV and optical wavelengths. By directly comparing with archival COS spectra taken in 2016, we will also search for changes in the strong emission lines that would imply evolution in the magnetic interaction between the white dwarf and secondary star.

OBSERVING DESCRIPTION

The optical light curve of AR Sco has evolved over the past decade so that the beat pulses from each pole are now nearly equal. We will make observations with COS in time-tag mode to directly compare the UV light curve and spectra of AR Sco with the COS data from 2015.

The position of AR Sco is from the GSC2 in the ICRS frame. The proper motion and parallax is from GAIA EDR3.

The light curve of AR Sco shows pulses separated by about 1 minute as well as an orbital modulation. The minimum flux observed in the 2015 COS data was between the pulses and around orbital phase 0. This minimum flux was 5e-16 erg/cm2/s/A. The spectrum is approximately flat, so we use this flux as that expected for acquistion using ACQ/image. From the COS acquistion ETC (COS.ta.1901985) we will reach a S/N ratio of 25 in 6s of exposure using MIRRORA/PSA. So we will take a 30s acquistion image to be certain of a high-quality image.

To protect COS from a flare on the M-dwarf, we have switched to acquistion using MirrorB and extended the acqusition exposure to 60s.

From the 2015 visit, the average flux of AR Sco over several orbits was 4.9e-15 erg/cm2/s/A. From the COS ETC (COS.sp.1902107), the time to fill the buffer is 10102 s. Reducing that number by 2/3 gives 6700 s.
The maximum flux during the 2015 visit was a pulse that peaked at 2e-14 erg/cm2/s/A and lasted for 25s. The COS ETC estimated the buffer fill time for this flux as 4400s. Two-thirds of this is 2900s.
To be safe, we are setting the Buffer Time to 1200 to 1400s depending on the exposure time.

The four FP-POS have been spread over the 5 HST orbits.

Proposal 17602 - Visit (01) - Understanding the Rapid Evolution in the Light Curve of the White Dwarf Pulsar AR Scorpii

Visit

Proposal 17602, Visit (01), implementation Mon Jul 29 20:01:05 GMT 2024

Diagnostic Status: No Diagnostics

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: (none)

Fixed Targets

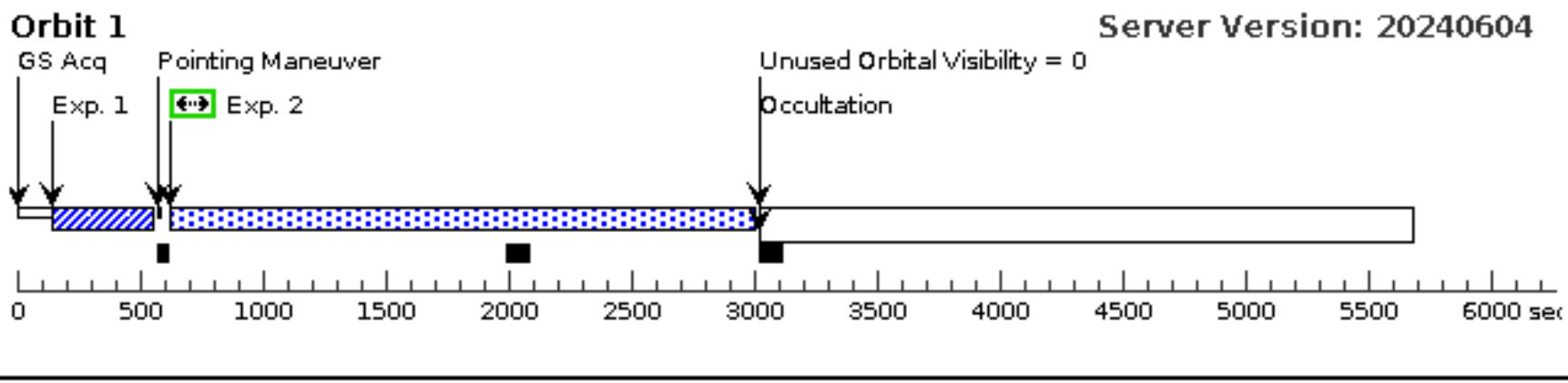
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	V-AR-SCO	RA: 16 21 47.2735 (245.4469729d) Dec: -22 53 10.10 (-22.88614d) Equinox: J2000	Proper Motion RA: 9.69 mas/yr Proper Motion Dec: -51.48900002041046 mas/yr Parallax: 0.0085437" Epoch of Position: 2000	V=14.75+/-1.0	Reference Frame: ICRS

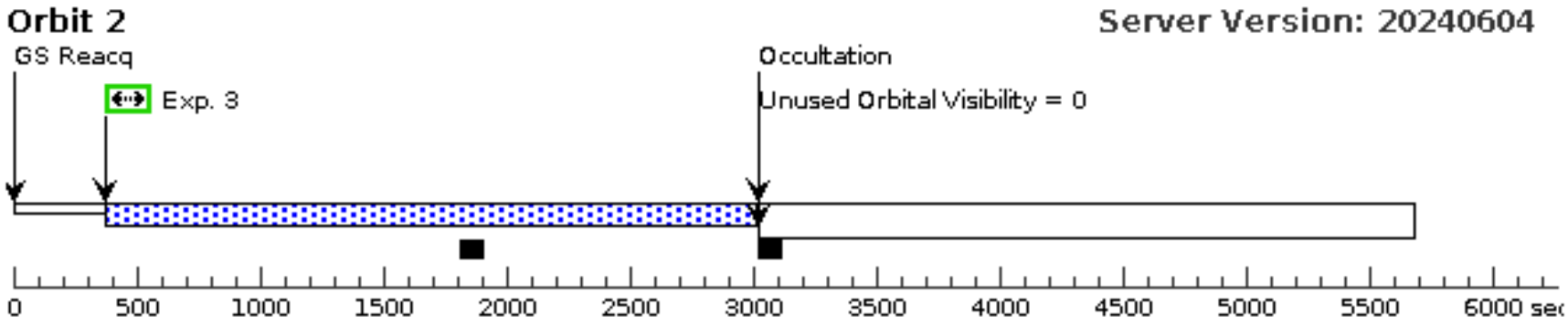
Comments: The position is from the GSC2 in ICRS reference frame. The proper motion and parallax are from GAIA EDR3.
Category=EXT-STAR
Description=[INTERMEDIATE POLAR]
Extended=NO

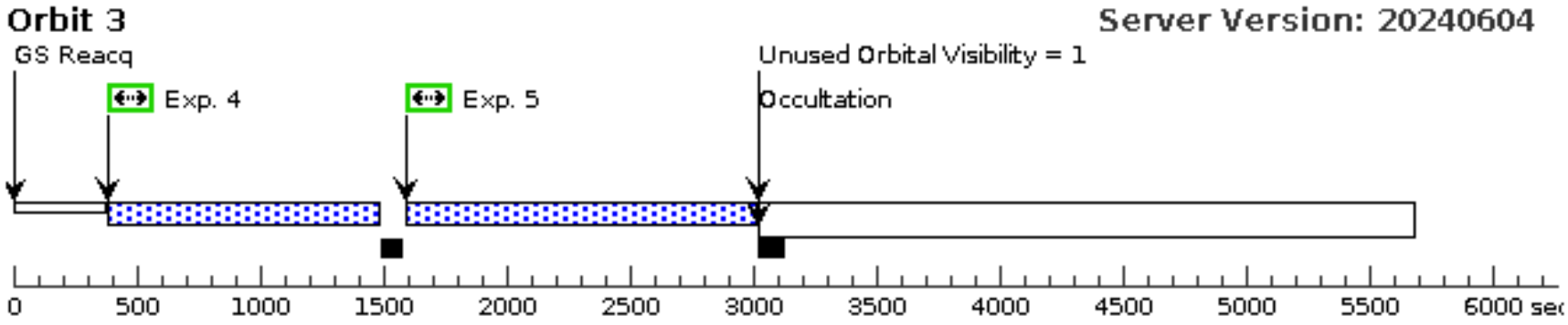
Exposures

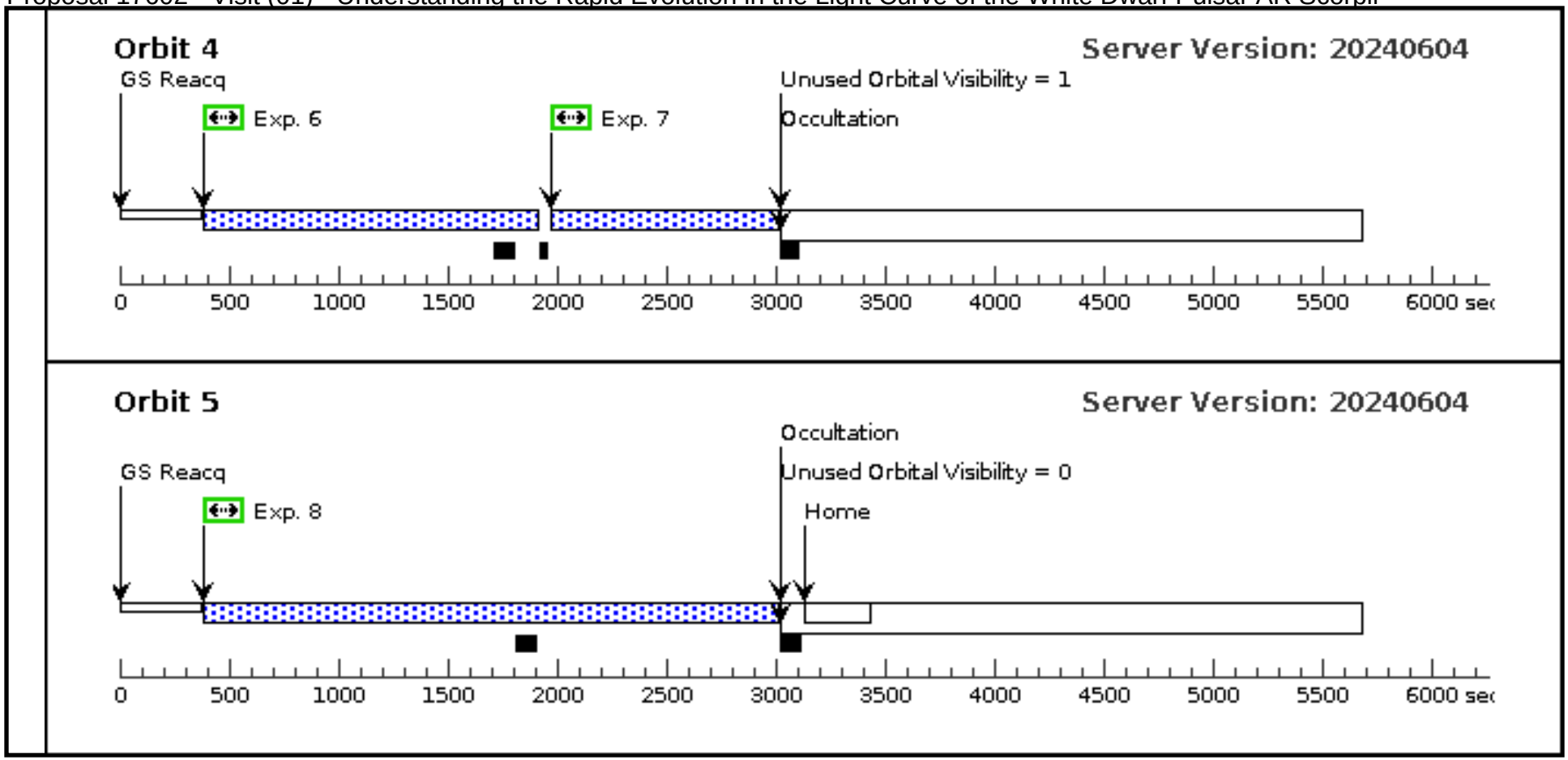
#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	acquisition (COS.ta.1901985)	(1) V-AR-SCO	COS/NUV, ACQ/IMAGE, PSA	MIRRORB				60 Secs (60 Secs) *[==>]*	***[1]***
Comments: The minimum flux observed during the 2015 visit was 5e-16 erg/cm2/s/A. Using that in the ETC provides and esimate of 6s to reach a S/N=25.									
2	science1 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1200; FP-POS=1			2309 Secs (2201 Secs) *[==>2201.0 Secs]*	***[1]***
3	science2 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1400; FP-POS=2			2683 Secs (2584 Secs) *[==>2584.0 Secs]*	***[2]***
4	science3 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1400; FP-POS=2			1100 Secs (1055 Secs) *[==>1055.0 Secs]*	***[3]***
5	science4 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1400; FP-POS=3			1411 Secs (1366 Secs) *[==>1366.0 Secs]*	***[3]***
6	science5 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1300; FP-POS=3			1530 Secs (1480 Secs) *[==>1480.0 Secs]*	***[4]***
7	science6 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1400; FP-POS=4			1038 Secs (988 Secs) *[==>988.0 Secs]*	***[4]***
8	science7 (COS.sp.1902100)	(1) V-AR-SCO	COS/FUV, TIME-TAG, PSA	G140L 1105 A	BUFFER-TIME=1400; FP-POS=4			2683 Secs (2584 Secs) *[==>2584.0 Secs]*	***[5]***

Orbit Structure





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