11685 - Supermassive Neutron Stars or Odd binaries: Searching for Companions to Pulsars NGC 6440B and Terzan 5J

Cycle: 17, 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) PSR-TERZAN5J-OFFSET	WFC3/IR	1	24-Jun-2008 22:54:06.0	yes
02	(2) PSR-NGC6440B	WFC3/IR WFC3/UVIS	1	24-Jun-2008 22:54:14.0	yes

2 Total Orbits Used

ABSTRACT

Recent sensitive pulsar searches of globular clusters uncovered four pulsars with very high inferred masses, between 1.7 and 2.7 solar masses. These strongly constrain the behaviour of matter in the ultra-dense interiors of neutron stars, since for most models such massive neutron stars could not exist. All four masses are inferred from the measured advance of periastron with time, under the assumption that it is due to General Relativity only. Here, we propose to test whether part of the observed periastron advance could be induced by the quadrupole moment of a suitably large, rotationally distorted companion. We infer the radii such companions need to have and show that they would be relatively bright, easily detectable with HST. For

one pulsar, M 5B, we find a plausible candidate counterpart in archival data. We propose to use 2 orbits with WFC3 to search for suitably large counterparts to two of the other systems, including the one with the highest inferred mass.

OBSERVING DESCRIPTION

Our goal is to detect possible companions to the pulsars NGC 6440B and Terzan 5J, at brightnesses appropriate for the case that the companions are sufficiently big to cause significant classical periastron advance.

For Terzan 5J, we infer a companion similar to a 0.4 Msun main-sequence star, with predicted magnitudes of V=31.5, I=26.8, J=23.5, and H=22.3. In the optical, the magnitudes cannot be reached in a single orbit, but in the infrared this is easy with WFC3/IR. We plan two dither boxes, of 4x350 s in F125W and 4x300 s in F160W. These times are sufficiently long to allow buffer dumps during the exposures. We fill the small amount of unused visibility with a partly exectuted RAPID sequence in F160W (where stars are predicted to be brightest, due to the large extinction). With this, we should detect the source at the above magnitudes at between 15 and 20 sigma in F125W and F160W (better including PSF fitting); these should thus be good detections even including the effects of crowding. We will point slightly towards the core of Terzan 5, in order to try to detect other pulsar companions. Nominally, we should be able to detect Terzan 5I, for which a massive neutron star has been inferred as well, but crowding may prevent it.

For NGC 6440B, for a radius of 1.1 Rsun and the lowest possible temperature, of 3200K (where the star is at the Hayashi limit), we predict V~27.4, I~22.3, and H~19.5. Obviously, the temperature can be higher, and indeed there is a possible counterpart in archival WFPC2 data at V~21.8. We aim to detect any possible counterpart in I and H at high significance, and somewhat hotter ones in V. This is possible in 1 orbit. Specifically, we plan to take dithered exposures of 300 and 350s in WFC3/IR F160W, 15, 348, and 394s in WFC3/UVIS F606W, and 10, 261, and 348s in WFC3/UVIS F814W, which completely fills the visibility without losing time to buffer dumps. This gives excellent detections for all possibilities.

Visit

Proposal 11685, Visit 01 Wed Jun 25 02:54:18 GMT 2008

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR

Special Requirements: (none)

Comments: - FOV including PSR TERZAN 5J as well as the cluster core, by pointing at an intermediate position
- Two dither boxes, one each for F125W (4xSTEP50/12=4x349s) and F160W (4xSTEP50/10=4x249s).
- Less time for F160W given huge reddening. In left-over time, include a RAPID/10=29s for F160W to get the bright stars (even) better.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-IR-DITHER-BOX-MIN Purpose=DITHER Number Of Points=4 Point Spacing=0.572 Line Spacing=0.365	Coordinate Frame=POS-TARG Pattern Orientation=18.528 Angle Between Sides=74.653 Center Pattern=false		(2), (3)

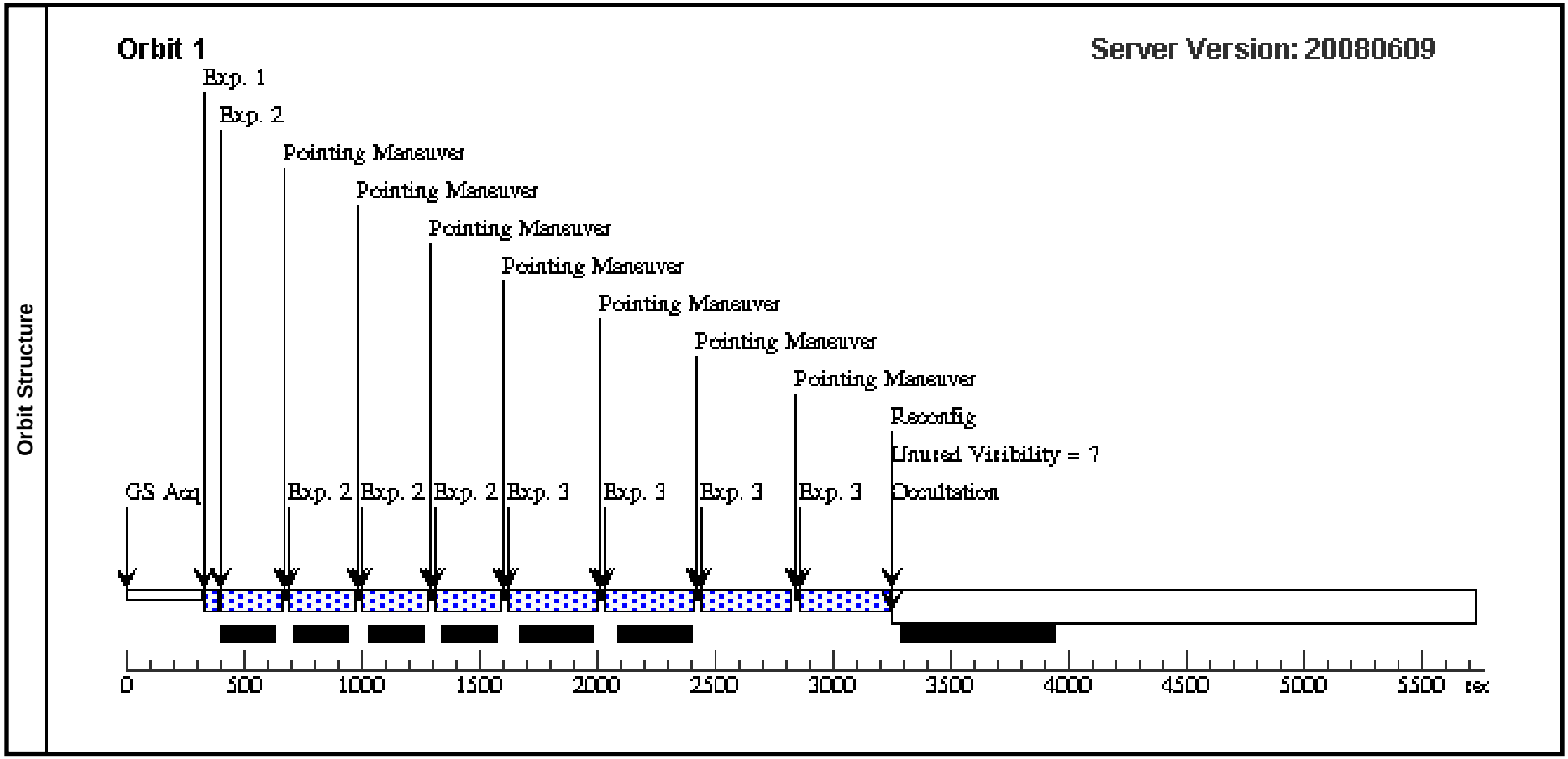
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PSR-TERZAN5J-OFFSET	RA: 17 48 4.4107 (267.0183779d) Dec: -24 47 10.05 (-24.78613d) Equinox: J2000		V=(?) Predicted J=23.5, H=22.3	Reference Frame: ICRS

Comments: This position is offset by exactly +0.4s and +30" from that of PSR Terzan 5J to ensure that the center of Terzan 5, and all the pulsars in it, will be observed together with primary target Terzan 5J. To determine the offset, I used that the cluster center is +0.86s and +52" away from Terzan 5J, but that Ter 5J should be at least 20" away from the detector edge, or at most 40" away from the detector centre. To be save, I used an offset of just over 30" total.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	Tezan 5J: WFC3/IR/F160W/bright stars	(1) PSR-TERZAN5J-OFFSET	WFC3/IR, MULTIACCUM, IR-FIX	F160W	NSAMP=10; SAMP-SEQ=RAPID			*[==>]*	***[1]***
	Comments: - Without this exposure, there was some unused visibility. It also serves to measure the brighter stars better in the band they likely are brightest. *- Use IR-FIX since the position is offset from the target and the core of Terzan 5.*								
2	Terzan 5J: WFC3/IR/F160W/dither box	(1) PSR-TERZAN5J-OFFSET	WFC3/IR, MULTIACCUM, IR-FIX	F160W	SAMP-SEQ=STEP50; NSAMP=10		Pattern 2-2 (1)	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
	Comments: - NSAMP set to minimum required to be able to dump data during integration. *- Use IR-FIX since the position is offset from the target and the core of Terzan 5.*								
3	Terzan 5J: WFC3/IR/F125W/dither box	(1) PSR-TERZAN5J-OFFSET	WFC3/IR, MULTIACCUM, IR-FIX	F125W	SAMP-SEQ=STEP50; NSAMP=12		Pattern 3-3 (1)	*[==>(Pattern 1)]* *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
	Comments: - Using F125W which is closer to J rather than wider F110W, since reddening makes latter only marginally more efficient. *- Use IR-FIX since the position is offset from the target and the core of Terzan 5.*								


Orbit Structure
Orbit 1
Server Version: 20080609
Exp. 1
Exp. 2
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Pointing Maneuver
Reconfig
Unused Visibility = ?
GS Acq
Exp. 2
Exp. 2
Exp. 2
Exp. 3
Exp. 3
Exp. 3
Exp. 3
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 11685, Visit 02 Wed Jun 25 02:54:19 GMT 2008

Diagnostic Status: No Diagnostics

Scientific Instruments: WFC3/IR, WFC3/UVIS

Special Requirements: (none)

Comments: - FOV automatically includes cluster core.
- One short and two long for each of UVIS/F606W and UVIS/F814W, and two intermediate-length sets of STEP50 for IR/F160W.
- Put WFC3/IR in between the WFC3/UVIS exposures since it allows one to dump a preceding UVIS image, and leave a relatively small image in the buffer, so that the next UVIS image can be shorter. (With IR in front, two IR dithers becomes impossible; with it at the end, cannot have a second short UVIS exposure.)

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(2)	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		(2), (5)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	PSR-NGC6440B	RA: 17 48 52.9529 (267.2206371d) Dec: -20 21 38.86 (-20.36079d) Equinox: J2000		V=21.8 Possible counterpart has V=21.8. Predictions V<27.4, I<23.3, H<19.5	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1	NGC 6440B: WFC3/UVIS/F606W/bright stars	(2) PSR-NGC6440B	WFC3/UVIS, ACCUM, UVIS	F606W	CR-SPLIT=NO			15 Secs *[==>]*	***[1]***
2	NGC 6440B: WFC3/UVIS/F606W two dithers	(2) PSR-NGC6440B	WFC3/UVIS, ACCUM, UVIS	F606W	CR-SPLIT=NO		Pattern 2-2 (2)	348 Secs *[==>(Pattern 1)]* *[==>394.0 Secs (Pattern 2)]*	***[1]***
	Comments: Second exposure made slightly longer than minimal required for buffer dump to use up visibility.								
3	NGC 6440B: WFC3/IR/F160W, 1 of 2	(2) PSR-NGC6440B	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP50; NSAMP=12			*[==>]*	***[1]***
	Comments: Exposure time chosen to just allow buffer dump from previous WFC3/UVIS exposure.								
4	NGC 6440B: WFC3/IR/F160W, 2 of 2	(2) PSR-NGC6440B	WFC3/IR, MULTIACCUM, IR	F160W	SAMP-SEQ=STEP50; NSAMP=11	POS TARG 0.424,0.474		*[==>]*	***[1]***
	Comments: - POS-TARG offset by 3.5, 3.5 pixels --as for WFC3-IR-DITHER-LINE-- to allow pixel phase sampling. *- Exposure time just long enough to dump buffer from previous exposure.*								

Exposures (continued)

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
5	NGC 6440B : WFc3/UVIS/F814W/two dithers	(2) PSR-NGC6440B	WFC3/UVIS, ACCUM, UVIS	F814W	CR-SPLIT=NO		Pattern 5-5 (2)	348 Secs *[==>261.0 Secs (Pattern 1)]* *[==>(Pattern 2)]*	***[1]***
	Comments: Exposure times chosen to allow buffer dumps, from previous WFC3/IR exposure, and first UVIS one. Buffer dumps from second and short following exposures to happen after occultation.								
6	NGC 6440B : WFC3/UVIS/F814/bright stars	(2) PSR-NGC6440B	WFC3/UVIS, ACCUM, UVIS	F814W	CR-SPLIT=NO	POS TARG 0.1058,0.0992		10 Secs *[==>]*	***[1]***
	Comments: Use POSTARG of 2.5, 2.5 pixels to keep same position as last integration.								

Orbit Structure