16792 - Completing the HST Parallax Legacy: M4

Cycle: 29, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Thomas M. Brown (PI) (Contact)	**Space Telescope Science Institute**	**tbrown@stsci.edu**
Dr. Stefano Casertano (CoI)	Space Telescope Science Institute	stefano@stsci.edu
Dr. Adam Riess (CoI)	The Johns Hopkins University	ariess@stsci.edu
Dr. David R. Soderblom (CoI)	Space Telescope Science Institute	drs@stsci.edu
Prof. Jay Strader (CoI)	Michigan State University	straderj@msu.edu
Prof. Don A. Vandenberg (CoI) (CSA Member)	University of Victoria	vandenbe@uvic.ca

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) M4	WFC3/UVIS	1	23-Jul-2021 09:02:20.0	yes

1 Total Orbits Used

ABSTRACT

There are only two globular clusters where a modest investment of HST time can yield a high-precision measurement of trigonometric parallax: NGC6397 and M4. The parallax to NGC6397 has been measured successfully with HST to 2% uncertainty. An important HST legacy would be the completion of this pair, by measuring the M4 parallax while HST can still do so.

In the context of the Galaxy's globular cluster system, these two clusters are complementary. NGC6397 is ancient (13 Gyr) and metal-poor ([Fe/H]=-2.02), while M4 is younger (11.5 Gyr) and of intermediate metallicity ([Fe/H]=-1.15). NGC6397 is a frequent fiducial for stellar population models, while M4 hosts a rich set of RR Lyrae stars that can be used to better calibrate the period-luminosity relationship. The utility of each cluster as a

population template and calibrator depends critically upon the distance uncertainties. The scarcity of population anchors in this regime is in contrast to the parameter space at younger ages (< 10 Gyr) and higher metallicities ([Fe/H] > -1), where many open clusters have high-precision parallaxes.

In a broader context, these two clusters represent an essential independent check on the parallaxes from the Gaia mission, which currently suffer from significant systematic errors on global, intermediate (20 degrees), and small (1 degree) scales, hampering distances to the Galaxy's globular clusters. If these errors are eventually resolved, HST parallaxes to globular clusters, independent of Gaia with distinct methodology, will provide an important validation. The observations we propose here will help anchor the distances to the entire globular cluster system of the Milky Way.

OBSERVING DESCRIPTION

Our proposal obtains a high-precision (2% 1-sigma uncertainty) distance to M4 using the spatial-scanning capability of WFC3/UVIS. Given the technical challenges, we have already done all of the preparations for the observations, thus ensuring feasibility. These preparations include selection of the best field and orientation, taking into account the number of cluster and field stars with useful scans (uncontaminated by neighbors), appropriate sampling of the parallax ellipse, schedulability, and scan position angle relative to the parallactic motion at the time of each observation. We have simulated the spatial scan analysis of this optimal field, using previous experience with spatial-scan observations as a guide. The signal-to-noise ratio in each 350-second spatial scan has been estimated using the extant photometry (Stetson+2014) and the throughput of the F606W filter. Our test Phase~II proposal indicates that in each epoch, we can execute 4 spatial scans in the F606W filter (forward, reverse, forward, reverse) of 3600-pixel length, plus unscanned images binned 2x2. These binned images will employ the F336W, F467M, F547M and F850LP filters. The resulting 4-filter photometry, when combined with ground-based spectroscopy of the field stars, will enable the required constraints on the absolute parallax reference frame. We will obtain multiple images in each filter for the entire scanned area, enabling cosmic-ray rejection and increased dynamic range. We also require one orbit (during the first epoch) dedicated to direct imaging; previous spatial-scanning programs were able to pack all of the direct imaging into the same orbits as the spatial scans, but recent shortening of the HST visibility windows, and the need to provide time when the telescope is not scanning (see the Call for Proposals), make it impossible to include all of the necessary imaging within the spatial-scanning orbits.

The proposal provides five single-orbit epochs of scans, at six-month intervals that sample the times of maximum parallactic motion; this final epoch should be scheduled between 28 Feb 2022 and 12 Mar 2022. Our test Phase II indicates that we would have at least a week of schedule availability for each epoch, at the appropriate orientation and date. Each spatial scan is nearly along the y-axis of the detector (0.05 degree offset), minimizing the effect of charge transfer inefficiency, but providing subsampling of the point spread function in the resolution direction (perpendicular to the scan).

Impact of reduced gyro mode: If HST were to enter reduced gyro mode, the reduced field of regard (approximately half of the current field of regard) would impact the scheduling. Currently, we are scanning at an angle nearly perpendicular to the parallax ellipse at times of maximum parallax offset, repeated every 6 months with 180 degree flips. In reduced gyro mode, those particular orientations will likely not be available at those particular times of the year, so we would need to explore other combinations of orientation and scheduling to see if the program is feasible, perhaps with a larger uncertainty on the parallax (using less optimal sampling of the parallax motion, and losing the ability to have the epochs at each end of the parallax motion mirror each other).

Visit

Proposal 16792, Visit 01, implementation Fri Jul 23 13:02:21 GMT 2021

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 298.9D TO 298.9 D; BETWEEN 28-FEB-2022:00:00:00 AND 12-MAR-2022:00:00:00

Comments: Should execute at the same position and orientation as GO-15933 Visit 03. Orient must be exactly 298.9 degrees (no range).

Diagnostics

(Visit 01) Warning (Orbit Planner): MERGING RULE VIOLATED DURING AUTOMATIC MERGING

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(Exposure 1 (Same Obset in Sequence 1-10 Non-Int in Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 2 (Same Obset in Sequence 1-10 Non-Int in Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 3 (Same Obset in Sequence 1-10 Non-Int in Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 8 (Same Obset in Sequence 1-10 Non-Int in Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 9 (Same Obset in Sequence 1-10 Non-Int in Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

(Exposure 10 (Same Obset in Sequence 1-10 Non-Int in Visit 01)) Warning (Form): FLASH level may be too high for this exposure or a long subexposure. See extended explanation in the diagnostic browser

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	M4	RA: 16 24 2.3040 (246.0096000d) Dec: -26 27 36.00 (-26.46000d) Equinox: J2000		V=7.12+/-0.1	Reference Frame: ICRS

Comments:
Category=STELLAR CLUSTER
Description=[GLOBULAR CLUSTER]

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	CR-SPLIT=NO; FLASH=20; BIN=2	POS TARG 0,-72	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	20 Secs (20 Secs) *[==>]*	***[1]***
2		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	CR-SPLIT=NO; FLASH=20; BIN=2	POS TARG 0,-72	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	40 Secs (40 Secs) *[==>]*	***[1]***
3		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F850LP	CR-SPLIT=NO; FLASH=20; BIN=2	POS TARG 0,-72	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	2 Secs (2 Secs) *[==>]*	***[1]***
4		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F606W		POS TARG 0,-72; SPATIAL SCAN 0.04 1,90.05 Degrees,Forward	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	350 Secs (350 Secs) *[==>]*	***[1]***
5		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F606W		POS TARG 0,-72; SPATIAL SCAN 0.04 1,90.05 Degrees,Reverse	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	350 Secs (350 Secs) *[==>]*	***[1]***
6		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F606W		POS TARG 0,-72; SPATIAL SCAN 0.04 1,90.05 Degrees,Forward	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	350 Secs (350 Secs) *[==>]*	***[1]***
7		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F606W		POS TARG 0,-72; SPATIAL SCAN 0.04 1,90.05 Degrees,Reverse	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	350 Secs (350 Secs) *[==>]*	***[1]***
8		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	CR-SPLIT=NO; FLASH=20; BIN=2	POS TARG 0,72	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	20 Secs (20 Secs) *[==>]*	***[1]***
9		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F336W	CR-SPLIT=NO; FLASH=20; BIN=2	POS TARG 0,72	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	40 Secs (40 Secs) *[==>]*	***[1]***
10		(1) M4	WFC3/UVIS, ACCUM, UVIS-CENTER	F850LP	CR-SPLIT=NO; FLASH=20; BIN=2	POS TARG 0,72	Sequence 1-10 Non-Int in Visit 01 Same Obset in Sequence 1-10 Non-Int in Visit 01	10 Secs (10 Secs) *[==>]*	***[1]***

Orbit Structure