14335 - The Proper Motion of Palomar 5 and its Tidal Tails

Cycle: 23, Proposal Category: GO

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*	*E-Mail*
Dr. Andreas H.W. Kuepper (PI) (Contact)	**Columbia University in the City of New York**	**ahk2154@columbia.edu**
Dr. Iskren Y. Georgiev (CoI) (ESA Member) (Contact)	Max-Planck-Institut fur Astronomie, Heidelberg	igeorgiev@rssd.esa.int
Dr. Paul Goudfrooij (CoI) (AdminUSPI)	Space Telescope Science Institute	goudfroo@stsci.edu
Dr. Luigi R. Bedin (CoI) (ESA Member)	Osservatorio Astronomico di Padova	luigi.bedin@oapd.inaf.it
Dr. Andrea J. Bellini (CoI)	Space Telescope Science Institute	bellini@stsci.edu
Dr. Patrick Cote (CoI)	Dominion Astrophysical Observatory	patrick.cote@nrc-cnrc.gc.ca
Prof. Marla C. Geha (CoI)	Yale University	marla.geha@yale.edu
Prof. Pavel Kroupa (CoI) (ESA Member)	Universitat Bonn, Argelander Institute for Astronomy	pavel@astro.uni-bonn.de
Dr. Marcel Pawlowski (CoI)	Case Western Reserve University	marcel.pawlowski@case.edu
Dr. Andrea Stolte (CoI) (ESA Member)	Universitat Bonn, Argelander Institute for Astronomy	astolte@astro.uni-bonn.de

VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(1) PAL5-EP1	ACS/WFC WFC3/UVIS	1	09-Oct-2015 21:44:40.0	yes
02	(2) PAL5-TT-QSO-W-EP1	ACS/WFC WFC3/UVIS	1	09-Oct-2015 21:44:43.0	yes
04	(3) PAL5-TT-QSO-E-EP1	ACS/WFC WFC3/UVIS	1	09-Oct-2015 21:44:45.0	yes

3 Total Orbits Used

ABSTRACT

The outer-halo Milky Way globular cluster Palomar 5 (Pal 5) shows prominent tidal tails (TT) extending over tens of degrees. Published ground-based proper motion (PM) measurements of Pal 5 are inconsistent with each other, and also with predictions from our numerical modeling (PM greater than 2 mas/yr in each component). Accurate PM would allow a detailed reconstruction of Pal 5's dissolution history and provide independent constraints on the shape of the Galactic potential. We propose to measure the PM of the Pal 5 cluster and a field 5 deg (2 kpc) along its TT with an accuracy of < 0.4 mas/yr via multi-epoch WFC3 and ACS observations in Cycles 20 and 22. We have identified a large number of QSOs and galaxies in these fields, which will allow us to achieve this accuracy on a three-year baseline. Combined with the large amount of available radial velocity data and detailed numerical modeling, the proposed observations will constrain the orbit of Pal 5 to greater accuracy than any other outer-halo satellite (< 30 km/s). Hence, it will enable us to tightly constrain the Galactic circular velocity and the flattening of the Galactic potential to less than 10% uncertainty. We will further use the PM-cleaned sample of stars in Pal 5 and its TT to unambiguously probe for variations of the present-day stellar mass function down to 0.2 Msun, enabling a direct estimate of Pal 5's mass loss rate. Together with the orbital information this will provide unique insights to the complex interplay of two-body relaxation and tidal shocking, which will have direct consequence for our understanding of the build-up of galaxy field populations and the evolution of cluster mass functions.

OBSERVING DESCRIPTION

We require two epochs of observations to measure the Pal 5 and its Tidal Tail (TT) proper motion (PM). The first epoch, as early in Cycle 20 as possible, and the second epoch late in Cycle 22, to guarantee a baseline of at least 3 yrs to achieve a PM precision of ~0.4 mas/yr. Each epoch will consist of three WFC3/UVIS-F814W pointings. One pointing will be on Pal 5, the other two will cover a QSO in a dense Tidal Tail region at 5 deg (about 2 kpc) projected distance from Pal5. Observations with the ACS/WFC-F606W and F814W in parallel will increase significantly the spatial coverage of Pal5 and its TT region and allow a deep probe to its stellar mass function.

For the two TT fields a second orbit in the 1st epoch will be used with WFC3/UVIS-F606W to measure the Mass Function (MF) down to 0.2 M_sol in combination with the WFC3/UVIS-F814W 1st orbit observation. Four exposures, one short at the beginning of the orbit and three long, per epoch with WFC3/UVIS-F814W will be used to improve the PSF sampling and correct for detector imperfections (e.g. bad pixels) and cosmic rays. The first short and long exposures will have the same positions, while the dithering for the others uses a spacing of 1.302 arcsec.

The specified orientation angles for the TT and Pal5 fields are chosen to allow earliest possible scheduling (17-24 Sept 2012) as well as to include in the WFC3 fields the QSO in the TT field (RA=231.64458, DEC=2.0367500), brigth background galaxies whose brightest globular clusters can be used as background reference and spectroscopically confirmed stars in Pal5 and its TT.

For the cluster ACS field we will use F606W in the first epoch and F814W in the second epoch to probe for variations of the MF beyond Pal 5's half-light radius.

Visit

Proposal 14335, Pal5-2EP-814/606 (01), implementation Sat Oct 10 01:44:46 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: SCHED 30%; ORIENT 88D TO 90 D

Comments: Second epoch

Diagnostics

(Pal5-2EP-814/606 (01)) Warning (Orbit Planner): PARALLELS SIGNIFICANTLY EXTEND ALIGNMENT TIME

(Pal5-2EP-814/606 (01)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

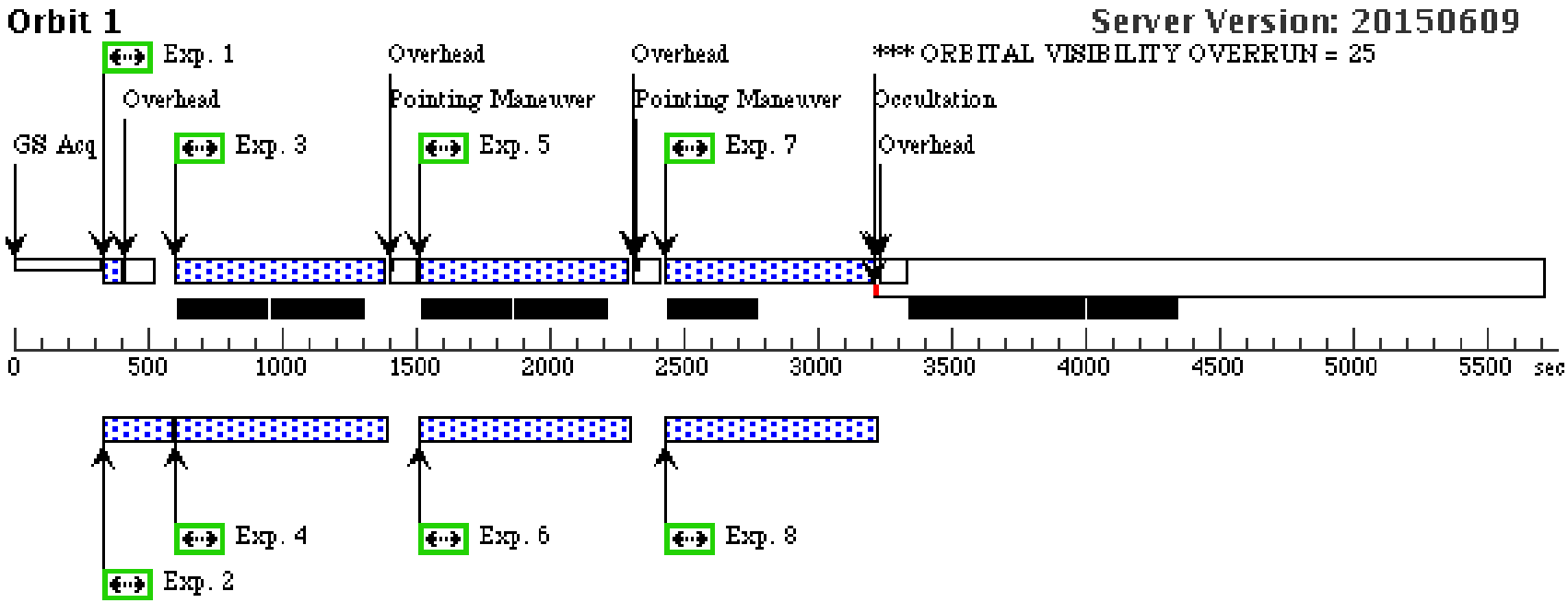
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	PAL5-EP1	RA: 15 16 5.4524 (229.0227183d) Dec: -00 07 59.26 (-.13313d) Equinox: J2000	Proper Motion RA: 2.5 mas/yr Proper Motion Dec: 2.5 mas/yr Epoch of Position: 2012.6	V=18	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	UVIS-814	(1) PAL5-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO; FLASH=11		Prime + Parallel Group 1-2 in Pal5-2EP-814/606 (01)	40 Secs (40 Secs) *[==>40.0 Secs]*	*[1]*
2	ACS-606	(1) PAL5-EP1	ACS/WFC, ACCUM, WFC	F606W	CR-SPLIT=NO; GAIN=2.0; FLASH=20		Prime + Parallel Group 1-2 in Pal5-2EP-814/606 (01)	40 Secs (40 Secs) *[==>40.0 Secs]*	*[1]*
3	UVIS-814	(1) PAL5-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	SAME POS AS 1	Prime + Parallel Group 3-4 in Pal5-2EP-814/606 (01)	785 Secs (786 Secs) *[==>786.0 Secs]*	*[1]*
4	ACS-606	(1) PAL5-EP1	ACS/WFC, ACCUM, WFC	F606W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 3-4 in Pal5-2EP-814/606 (01)	665 Secs (664 Secs) *[==>664.0 Secs]*	*[1]*
5	UVIS-814	(1) PAL5-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	POS TARG 1.302,1.302	Prime + Parallel Group 5-6 in Pal5-2EP-814/606 (01)	785 Secs (786 Secs) *[==>786.0 Secs]*	*[1]*
6	ACS-606	(1) PAL5-EP1	ACS/WFC, ACCUM, WFC	F606W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 5-6 in Pal5-2EP-814/606 (01)	665 Secs (664 Secs) *[==>664.0 Secs]*	*[1]*
7	UVIS-814	(1) PAL5-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	POS TARG 2.604,2.604	Prime + Parallel Group 7-8 in Pal5-2EP-814/606 (01)	785 Secs (786 Secs) *[==>786.0 Secs]*	*[1]*
8	ACS-606	(1) PAL5-EP1	ACS/WFC, ACCUM, WFC	F606W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 7-8 in Pal5-2EP-814/606 (01)	665 Secs (664 Secs) *[==>664.0 Secs]*	*[1]*

Orbit Structure



Visit

Proposal 14335, Pal5-TT-2EP-814-QSO-W (02), implementation Sat Oct 10 01:44:47 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: ORIENT 84D TO 100 D

Comments: Second Epoch Tidal Tail field West of the QSO

Diagnostics

(Pal5-TT-2EP-814-QSO-W (02)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

(Pal5-TT-2EP-814-QSO-W (02)) Warning (Orbit Planner): PARALLELS SIGNIFICANTLY EXTEND ALIGNMENT TIME

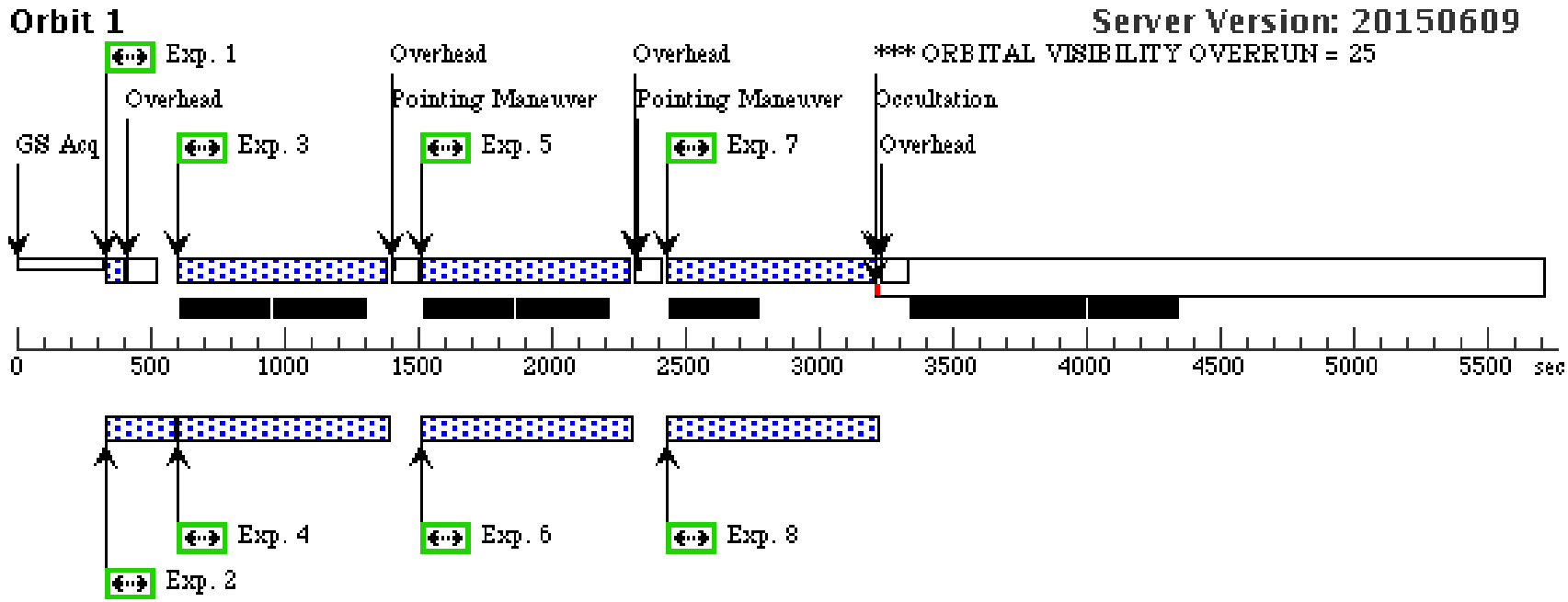
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	PAL5-TT-QSO-W-EP1	RA: 15 26 39.3505 (231.6639604d) Dec: +02 01 59.64 (2.03323d) Equinox: J2000		V=21	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	UVIS-814	(2) PAL5-TT-QSO-W-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO; FLASH=11		Prime + Parallel Group 1-2 in Pal5-TT-2EP-814-QSO-W (02)	40 Secs (40 Secs) *[==>40 Secs]*	 ***[1]***
2	ACS-814	(2) PAL5-TT-QSO-W-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0; FLASH=20		Prime + Parallel Group 1-2 in Pal5-TT-2EP-814-QSO-W (02)	40 Secs (40 Secs) *[==>40 Secs]*	 ***[1]***
3	UVIS-814	(2) PAL5-TT-QSO-W-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	SAME POS AS 1	Prime + Parallel Group 3-4 in Pal5-TT-2EP-814-QSO-W (02)	786 Secs (786 Secs) *[==>]*	 ***[1]***
4	ACS-814	(2) PAL5-TT-QSO-W-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 3-4 in Pal5-TT-2EP-814-QSO-W (02)	664 Secs (664 Secs) *[==>]*	 ***[1]***
5	UVIS-814	(2) PAL5-TT-QSO-W-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	POS TARG 1.302,1.302	Prime + Parallel Group 5-6 in Pal5-TT-2EP-814-QSO-W (02)	786 Secs (786 Secs) *[==>]*	 ***[1]***
6	ACS-814	(2) PAL5-TT-QSO-W-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 5-6 in Pal5-TT-2EP-814-QSO-W (02)	664 Secs (664 Secs) *[==>]*	 ***[1]***
7	UVIS-814	(2) PAL5-TT-QSO-W-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	CR-SPLIT=NO; BIN=NONE	POS TARG 2.604,2.604	Prime + Parallel Group 7-8 in Pal5-TT-2EP-814-QSO-W (02)	786 Secs (786 Secs) *[==>]*	 ***[1]***
8	ACS-814	(2) PAL5-TT-QSO-W-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 7-8 in Pal5-TT-2EP-814-QSO-W (02)	664 Secs (664 Secs) *[==>]*	 ***[1]***

Orbit Structure



Visit

Proposal 14335, Pal5-TT-2EP-814-QSO-E (04), implementation Sat Oct 10 01:44:47 GMT 2015

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS, ACS/WFC

Special Requirements: ORIENT 84D TO 86 D

Comments: Second Epoch Tidal Tail field East of the QSO

Diagnostics

(Pal5-TT-2EP-814-QSO-E (04)) Warning (Orbit Planner): PARALLELS SIGNIFICANTLY EXTEND ALIGNMENT TIME

(Pal5-TT-2EP-814-QSO-E (04)) Warning (Orbit Planner): ORBITAL VISIBILITY OVERRUN

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(3)	PAL5-TT-QSO-E-EP1	RA: 15 26 34.0681 (231.6419504d) Dec: +02 03 34.67 (2.05963d) Equinox: J2000		V=21	Reference Frame: ICRS

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	UVIS-814	(3) PAL5-TT-QSO-E-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO; FLASH=11		Prime + Parallel Group 1-2 in Pal5-TT-2EP-814-QSO-E (04)	40 Secs (40 Secs) *[==>40 Secs]*	 ***[1]***
2	ACS-814	(3) PAL5-TT-QSO-E-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0; FLASH=20		Prime + Parallel Group 1-2 in Pal5-TT-2EP-814-QSO-E (04)	40 Secs (40 Secs) *[==>40 Secs]*	 ***[1]***
3	UVIS-814	(3) PAL5-TT-QSO-E-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	SAME POS AS 1	Prime + Parallel Group 3-4 in Pal5-TT-2EP-814-QSO-E (04)	786 Secs (786 Secs) *[==>]*	 ***[1]***
4	ACS-814	(3) PAL5-TT-QSO-E-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 3-4 in Pal5-TT-2EP-814-QSO-E (04)	664 Secs (664 Secs) *[==>]*	 ***[1]***
5	UVIS-814	(3) PAL5-TT-QSO-E-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	BIN=NONE; CR-SPLIT=NO	POS TARG 1.302,1.302	Prime + Parallel Group 5-6 in Pal5-TT-2EP-814-QSO-E (04)	786 Secs (786 Secs) *[==>]*	 ***[1]***
6	ACS-814	(3) PAL5-TT-QSO-E-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 5-6 in Pal5-TT-2EP-814-QSO-E (04)	664 Secs (664 Secs) *[==>]*	 ***[1]***
7	UVIS-814	(3) PAL5-TT-QSO-E-EP1	WFC3/UVIS, ACCUM, UVIS-FIX	F814W	CR-SPLIT=NO; BIN=NONE	POS TARG 2.604,2.604	Prime + Parallel Group 7-8 in Pal5-TT-2EP-814-QSO-E (04)	786 Secs (786 Secs) *[==>]*	 ***[1]***
8	ACS-814	(3) PAL5-TT-QSO-E-EP1	ACS/WFC, ACCUM, WFC	F814W	CR-SPLIT=NO; GAIN=2.0		Prime + Parallel Group 7-8 in Pal5-TT-2EP-814-QSO-E (04)	664 Secs (664 Secs) *[==>]*	 ***[1]***

Orbit Structure