11783 - The Dynamical Mass of the Bright Cepheid Polaris

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) POLARIS (2) POLARIS-B	WFC3/UVIS	1	13-Jul-2009 21:54:08.0	yes

1 Total Orbits Used

ABSTRACT

Cepheid variables are of central importance in Galactic and extragalactic astronomy. They are the primary standard candles for measuring extragalactic distances, and they provide critical tests of stellar-evolution theory. Surprisingly, however, until now there was not a single Cepheid with a purely dynamical measurement of its mass.

Polaris (alpha UMi) is the nearest and brightest of all Cepheids. It offers the unique opportunity to measure the dynamical mass of a Cepheid, because it is in a binary system for which a single-lined spectroscopic orbit is already available. In Cycle 14, we resolved the system in the UV using ACS/HRC, thus providing the first direct detection of the companion, as well as a first approximation to the dynamical mass. In the present proposal we request one HST orbit per year for the next 3 Cycles, in order to refine the visual orbit. Combined with the HST/FGS parallax (see below), this program will provide an accurate mass for the Cepheid (the error should be about 0.5 Msun by Cycle 17), and the only one based purely on dynamical information. Only HST's combination of high spatial resolution and UV sensitivity can achieve this result.

The parallax is a key ingredient in the mass determination. In an ongoing multi-year program (GO-9888, GO-10113, GO-10482), we are using the FGS to improve significantly upon the Hipparcos parallax of Polaris. The continued ACS/HRC imaging proposed here (updated to WFC3 following SM4) will thus provide extremely valuable astrophysical information from a very modest additional investment of observing time.

OBSERVING DESCRIPTION

The observations, originally planned for ACS/HRC, will be made with WFC3/UVIS. We will use the FQ232N quad filter, which suppresses the light of Polaris Aa so that it will not saturate. We will take a series of 4-point dithered exposures. One set will be on Polaris A, 0.5 sec each, and a second set also on Polaris A at 0.7 sec each. One extra 0.7-sec exposure is also made, to fill the orbit. According to the WFC3 ETC, even the 0.7 sec exposures should not saturate. We will then move the single star Polaris B to the same chip position and take a 4-point dither set of 45-sec exposures, for the purpose of providing a PSF reference image. We will fill the orbit by taking one more 45-sec exposure on Polaris B.

Visit

Proposal 11783, Visit 01, implementation Tue Jul 14 01:54:13 GMT 2009

Diagnostic Status: Warning

Scientific Instruments: WFC3/UVIS

Special Requirements: ORIENT 240D TO 280 D; ORIENT 330D TO 10 D; ORIENT 60D TO 100 D; ORIENT 150D TO 190 D; BETWEEN 01-AUG-2009:00:00:00 AND 01-APR-2010:00:00:00

Comments: ORIENT is chosen to place Polaris Ab at 45 +/- 20 deg relative to the diffraction spikes of Polaris Aa. BETWEEN dates added to assure observation is completed by middle of Cycle 17, to maintain proper cadence for this long-term monitoring program.

Diagnostics

(Exposure 1 (Pattern 1, Exps 1-1)) Warning (Form): POS TARG & PATTERN should be used carefully with ACS/WFPC2 ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

(Exposure 2 (Pattern 1, Exps 2-2)) Warning (Form): POS TARG & PATTERN should be used carefully with ACS/WFPC2 ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

(Exposure 3 (Visit 01)) Warning (Form): POS TARG & PATTERN should be used carefully with ACS/WFPC2 ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

(Exposure 4 (Pattern 1, Exps 4-4)) Warning (Form): POS TARG & PATTERN should be used carefully with ACS/WFPC2 ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

(Exposure 5 (Visit 01)) Warning (Form): POS TARG & PATTERN should be used carefully with ACS/WFPC2 ramp or WFC3 quad filters as central wavelengths & transmission efficiencies vary within the apertures.

Patterns

#	Primary Pattern		Secondary Pattern	Exposures
(1)	Pattern Type=WFC3-UVIS-DITHER-BOX Purpose=DITHER Number Of Points=4 Point Spacing=0.173 Line Spacing=0.112	Coordinate Frame=POS-TARG Pattern Orientation=23.884 Angle Between Sides=81.785 Center Pattern=true		(1), (2), (4)

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	POLARIS Alt Name1: ALPHA-UMI	RA: 02 31 29.2000 (37.8716667d) Dec: +89 15 45.90 (89.26275d) Equinox: J2000	Proper Motion RA: 0.230315s/yr Proper Motion Dec: -0.01175"/yr Parallax: 0.00756" Epoch of Position: 1991.25	V=1.98+/-0.1	Reference Frame: ICRS
Comments: Coordinates are from Hipparcos, but are adjusted so as to place the center of the field of view one-third of the way between Polaris A and Polaris B (which are separated by 18"). This will place both stars within the WFC3 quad filter field of view, as desired, with Polaris A about 6" from the center.					
(2)	POLARIS-B Alt Name1: ALPHA-UMI-B	RA: 02 30 16.6500 (37.5693750d) Dec: +89 15 34.30 (89.25953d) Equinox: J2000	Proper Motion RA: 0.230315s/yr Proper Motion Dec: -0.01175"/yr Parallax: 0.00756" Epoch of Position: 1991.25	V=8.5+/-0.2	Reference Frame: ICRS
Comments: These coordinates will place Polaris B at the same location in the FOV as Polaris A, as desired.					

Exposures

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
1		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO	GS ACQ SCENARIO BASE1B3	Pattern 1, Exps 1-1 (1)	0.5 Secs	
								[==>(Pattern 1)]	***[1]***
								[==>(Pattern 2)]	
								[==>(Pattern 3)]	
								[==>(Pattern 4)]	

Exposures (continued)

#	Label	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time/[Actual Dur.]	Orbit
2		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO		Pattern 1, Exps 2-2 (1)	0.7 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
3		(1) POLARIS	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO	POS TARG 0,0		0.7 Secs	
								[==>]	***[1]***
4		(2) POLARIS-B	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO		Pattern 1, Exps 4-4 (1)	45 Secs	
								[==>(Pattern 1)] *[==>(Pattern 2)]* *[==>(Pattern 3)]* *[==>(Pattern 4)]*	***[1]***
5		(2) POLARIS-B	WFC3/UVIS, ACCUM, UVIS-QUAD-SUB	FQ232N	CR-SPLIT=NO	POS TARG 0,0		45 Secs	
								[==>]	***[1]***

Orbit Structure