10919 - Eclipsing Binaries in the Local Group: II - Calibration of the Zeropoint of the Cosmic Distance Scale and Fundamental Properties of Stars in M33

Cycle: 15, 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) D33-J013346.2+304439.9	WFPC2	1	10-Sep-2007 21:03:31.0	yes
02	(1) D33-J013346.2+304439.9	ACS/SBC	1	10-Sep-2007 21:03:36.0	yes

2 Total Orbits Used

ABSTRACT

The Great Spiral Galaxy in Triangulum (M33) is potentially a crucial calibrator for the Cosmic Distance Scale, and thus for determining the age and evolution of the Universe. M33 is viewed face-on, has a simple geometry, large and diverse stellar populations, and morphologies similar to our Galaxy and other more distant galaxies used for distance determinations. Yet currently the M33 distance (d ~ 830 +/- 110 kpc) still has measurement

dispersions of 10-15%. We have demonstrated, in our work on the LMC and M31 distances, that double-line eclipsing binaries can serve as excellent "standard candles." Distances derived from eclipsing binaries are basically geometric and essentially free from many assumptions and uncertainties that plague other less direct methods, such as metallicity differences and calibration zeropoints. The absolute radii of the component stars of eclipsing binaries can be determined to better than a few percent from the time-tested analyses of their light and radial velocity curves. With accurate determinations of radii, temperatures, and ISM absorption it is possible to determine reliable distances. We are extending our program of using eclipsing binaries as standard candles to determine an accurate distance to M33. As a first step, we are proposing to carry out HST/ACS spectrophotometry of a well suited ~19th mag ~O7 + ~O7 eclipsing binary system in M33 that has been previously observed from the ground. HST/ACS prism/grism low-resolution spectrophotometry (118-850 nm) is the only missing key element of this program and is used to determine more reliable values for T_eff, [Fe/H], and ISM extinction. These quantities, when combined with the results from existing light and radial velocity curves for the target, yield the stellar masses, radii, luminosities and, importantly, the distance. The proposed HST/ACS program can be carried out effectively with only 1 HST orbit. Based on our previous experience, we expect to reduce the uncertainty of the M33 distance to better than 5-7%, thereby leading to a firmer calibration of the Cosmic Distance Scale and the zeropoint of the Hubble Constant (Ho).

OBSERVING DESCRIPTION

In this initial study we are requesting observations of the M33 EB target that has existing light and radial velocity curves. For this program, 2 HST orbits have been assigned. We have used the APT in its Phase II mode to perform detailed simulations of the exposure times and orbit planning to optimize the resulting datasets. According to the HST orbital constraints and the declination of our target, a maximum visibility of 3180 s is available per orbit. The optimum times for observing our target are in the months of July and September. Our simulations indicate that only one HST orbit is sufficient to achieve full spectral coverage (FUV to near-IR) with the necessary S/N to fulfill the program's goals. Time permitting, we will also secure a V-band image of the target and the surrounding stars in the FOV in order to provide an accurate photometric anchor for the ACS spectrophotometry. Also, having this image will be useful for exploring the region close to the target for fainter companions.

We will use the ACS/SBC and WFPC2 to obtain complete spectro/photometric coverage, from 118 to 814 nm. Multiple WPFC2 filters and the ACS/SBC PR110L prism will used. As discussed by Fitzpatrick & Massa (1999, ApJ, 525, 1011) this extended wavelength coverage uniquely disentangles the stellar and interstellar parameters, yielding the quantities: Teff, log g, [Fe/H], E(B-V), and AV. For example, the near UV includes

the ~220 nm ISM dust absorption feature that will permit a firm determination of the ISM reddening of the target. Presently the determination of the AV for this star is one of the major contributions to the error budget. Finally, given the eccentric orbit of this EB system, additional eclipse timings will provide the apsidal motion of the system and important information on the internal structure of its components. We are familiar with using the ACS prism setup given our two previous proposals, each making use of HST/ACS low resolution spectrophotometry.

Our exposure estimates were carried out using the latest version of the ACS/WFPC2 spectroscopic and imaging online exposure time calculators. We assumed the intrinsic energy distribution of an O7 V type star and an extinction corresponding to E(B-V)~0.14 mag, estimated already from existing B and V photometry of the target. We estimate that S/N in excess of ~40:1 is necessary to secure a spectrum with sufficient quality to allow an accurate determination of the stellar and interstellar parameters. The calculations indicate that an S/N of ~40:1 is obtained with an exposure time of 485 s for PR110L. The following photometric estimates were made for the WFPC2: F170W - 760 s, F218W - 1200 s, F255W - 700 s, F300W - 350 s, F336W - 450 s, F439W - 450 s, F555W - 120 s, F675W, 200 s and F814W - 300 s. This will result in data comparable (in terms of S/N and spectral coverage) to those shown in Fig. 2 for the LMC system HV 982. The orbit planning software confirms that such exposure times nicely fit within an HST orbit when all instrumental overheads are taken into account. From ground-based and WFPC2 observations, the coordinates of the proposed target are known to a precision better than 0.2 arcsec and no problems with target acquisition are expected.

Visit

Proposal 10919, Visit 01, implementation Tue Sep 11 01:03:39 GMT 2007

Diagnostic Status: Warning

Scientific Instruments: WFPC2

Special Requirements: PCS MODE FINE; ORIENT 300.0D TO 10.0 D; ORIENT 120.0D TO 200.0 D; Period 4.8938 D AND ZERO-PHASE JD2451451.404

Diagnostics

(Visit 01) Warning (OP): EXPOSURE TIME DECREASED FOR WFPC

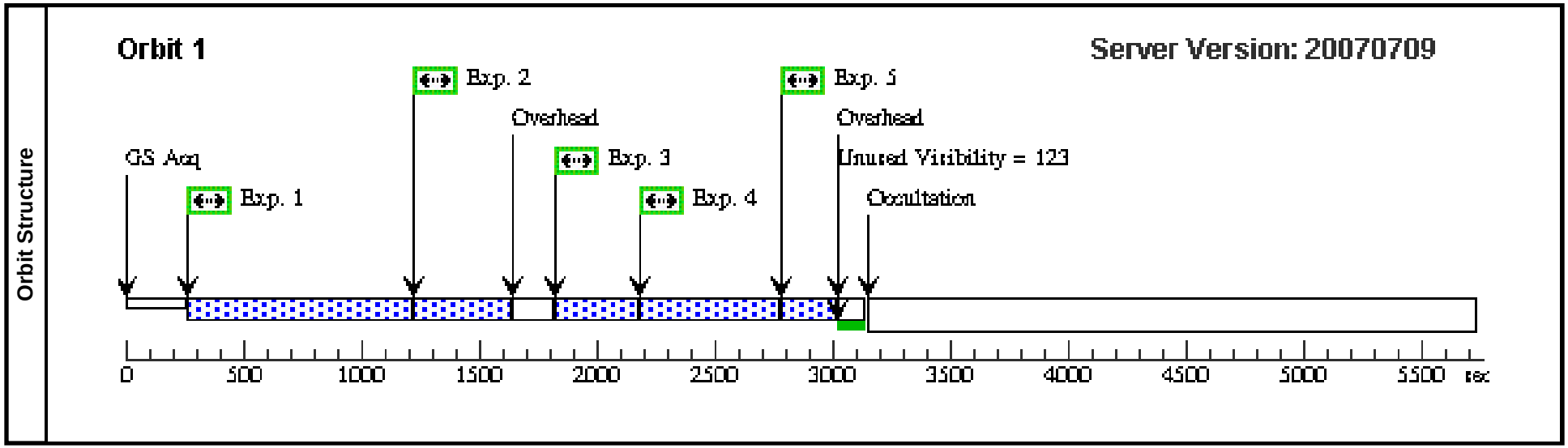
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	D33-J013346.2+304439.9	RA: 01 33 46.1200 (23.4421667d) Dec: +30 44 39.30 (30.74425d) Equinox: J2000		V=19.51+/-0.05	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/[Actual Dur.]	Orbit
1		(1) D33-J013346.2+304439.9	WFPC2, IMAGE, WFALL	F218W	CR-SPLIT=NO	PHASE 0.55 TO 0.85; GS ACQ SCENARIO SINGLE	Sequence 1-5 Non-Int	750.0 Secs *[==>]*	*[1]*
2		(1) D33-J013346.2+304439.9	WFPC2, IMAGE, WFALL	F300W	CR-SPLIT=NO		Sequence 1-5 Non-Int	300.0 Secs *[==>]*	*[1]*
3		(1) D33-J013346.2+304439.9	WFPC2, IMAGE, WFALL	F555W	CR-SPLIT=NO		Sequence 1-5 Non-Int	160.0 Secs *[==>]*	*[1]*
4		(1) D33-J013346.2+304439.9	WFPC2, IMAGE, WFALL	F336W	CR-SPLIT=NO		Sequence 1-5 Non-Int	350.0 Secs *[==>]*	*[1]*
5		(1) D33-J013346.2+304439.9	WFPC2, IMAGE, WFALL	F814W	CR-SPLIT=NO		Sequence 1-5 Non-Int	160.0 Secs *[==>]*	*[1]*


Orbit Structure
Orbit 1
Server Version: 20070709
GS Acq
Exp. 1
Exp. 2
Overhead
Exp. 3
Exp. 4
Exp. 5
Overhead
Unused Visibility = 123
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec

Visit

Proposal 10919, Visit 02, implementation Tue Sep 11 01:03:40 GMT 2007

Diagnostic Status: No Diagnostics

Scientific Instruments: ACS/SBC

Special Requirements: ORIENT 300.0D TO 10.0 D; ORIENT 120.0D TO 200.0 D; Period 4.8938 D AND ZERO-PHASE JD2451451.404

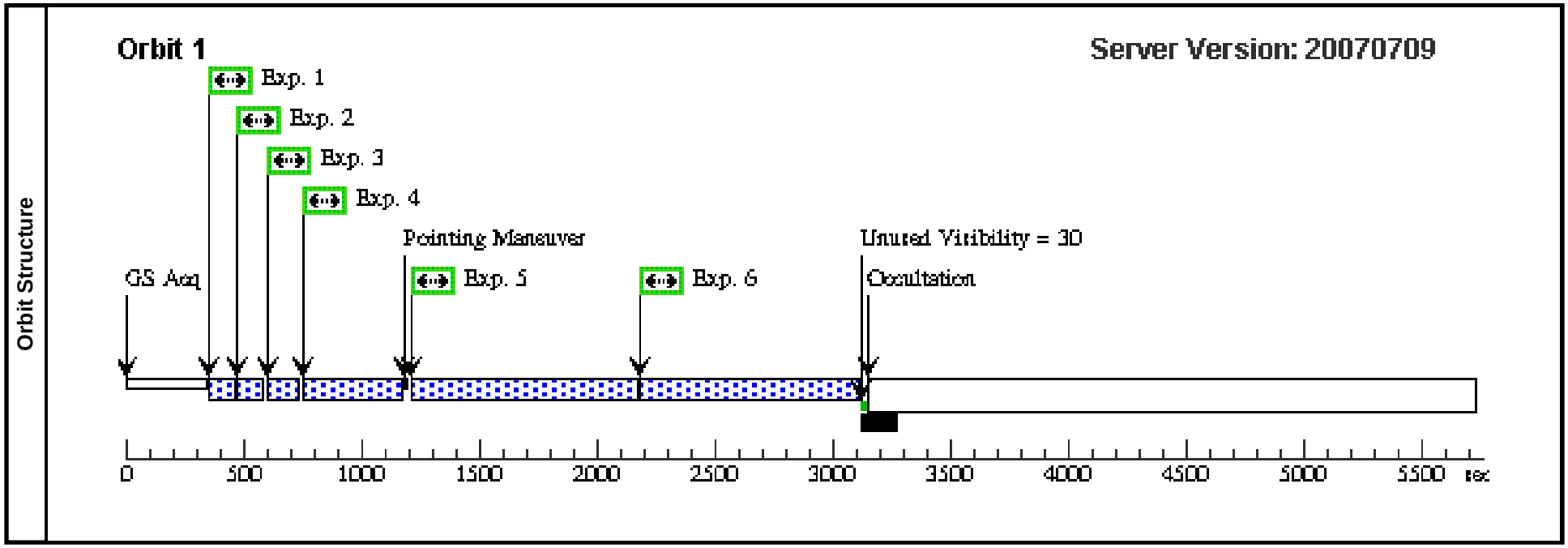
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(1)	D33-J013346.2+304439.9	RA: 01 33 46.1200 (23.4421667d) Dec: +30 44 39.30 (30.74425d) Equinox: J2000		V=19.51+/-0.05	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/[Actual Dur.]	Orbit
1		(1) D33-J013346.2+304439.9	ACS/SBC, ACCUM, SBC	F115LP		PHASE 0.55 TO 0.85	Sequence 1-6 Non-Int	40.0 Secs *[==>]*	 ***[1]***
2		(1) D33-J013346.2+304439.9	ACS/SBC, ACCUM, SBC	F125LP			Sequence 1-6 Non-Int	70.0 Secs *[==>]*	 ***[1]***
3		(1) D33-J013346.2+304439.9	ACS/SBC, ACCUM, SBC	F140LP			Sequence 1-6 Non-Int	85.0 Secs *[==>]*	 ***[1]***
4		(1) D33-J013346.2+304439.9	ACS/SBC, ACCUM, SBC	F165LP			Sequence 1-6 Non-Int	370.0 Secs *[==>]*	 ***[1]***
5		(1) D33-J013346.2+304439.9	ACS/SBC, ACCUM, SBC	PR110L			Sequence 1-6 Non-Int	900.0 Secs *[==>]*	 ***[1]***
6		(1) D33-J013346.2+304439.9	ACS/SBC, ACCUM, SBC	PR110L			Sequence 1-6 Non-Int	900.0 Secs *[==>]*	 ***[1]***


Orbit Structure
Orbit 1
Server Version: 20070709
Exp. 1
Exp. 2
Exp. 3
Exp. 4
Pointing Maneuver
Exp. 5
Exp. 6
Unused Visibility = 3D
GS Acq
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
sec