



15237 - Resolving the discrepancy in the mass determination from the gravitational redshift of Sirius B

Cycle: 25, Proposal Category: GO
(Availability Mode: SUPPORTED)

INVESTIGATORS

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VISITS

<i>Visit</i>	<i>Targets used in Visit</i>	<i>Configurations used in Visit</i>	<i>Orbits Used</i>	<i>Last Orbit Planner Run</i>	<i>OP Current with Visit?</i>
01	(1) SIRIUS-B (2) SIRIUS-A WAVE	STIS/CCD	1	19-Oct-2017 20:00:19.0	yes

1 Total Orbits Used

ABSTRACT

White dwarfs (WDs) are the remnants of stars with initial masses less than 8Msol. Many studies make use of WDs as tools to help in other areas of astronomy, for example, to determine the ages of stellar populations. The white dwarf mass-radius relation is a foundation of many studies which are only possible because the WD mass-radius relation allows us to calculate these parameters when they cannot be independently observed.

Despite its well accepted theoretical basis, the white dwarf mass-radius relation has been difficult to test observationally due to the difficulty of making observations of sufficient precision. We propose STIS observations of Sirius B, which is the nearest WD, to obtain the spectrum of the H alpha absorption line which can be used to measure the mass of the WD through the gravitational redshift method. Previous HST observations of Sirius B have allowed us to measure the mass to a high level of precision. However this has uncovered a significant unexplained discrepancy between the mass calculated using the gravitational redshift method and the astrometrically determined mass. Our aim is to resolve this discrepancy by using the traditional method of measuring the gravitational red shift of the WD relative to the luminous primary, in this case Sirius A. We will measure the wavelengths of the H-alpha lines in both Sirius B and A using the same STIS G750M grating during the same visit. This will remove many of the systematic uncertainties affecting previous observations. This will either allow us to confirm the validity of this fundamental method and the mass-radius relationship, or it may uncover a gap in our understanding which needs to be addressed.

OBSERVING DESCRIPTION

Observation strategy

The aim of the observation is to obtain spectra of both Sirius A and B covering the H alpha (6564A) line using the same instrumental setup so that the shift in the wavelength of the Sirius B line can be compared to the position of the Sirius A line. The observations should take place in the same orbit with no change to the setup to minimise any uncertainty due to changes in the instrument.

The strategy will be to acquire Sirius B and do a peak up to center it in the 52x0.05E1 slit and take a set of 2 G750M spectra. Then immediately move the telescope to Sirius A and take a set of 2 spectra with the same slit and grating. No peak up will be performed for Sirius A because the peakup would require a change in the aperture used to prevent saturation.

The small angle maneuver accuracy for the distance of 11 arc sec from B to A is estimated at 0".0045 so this should be precise enough to place the target in the 52x0.05 slit. The same guide stars can be used throughout as the separation of A and B is only 11 arc sec.

The E1 pseudo aperture which places the spectra closer to the CCD readout will be used to avoid problems with charge transfer efficiency losses.

We will then change to the 32x0.05NDC aperture to peak up on Sirius A to align the target in the slit as accurately as possible.

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The aperture will be changed back to 52x0.05 to take 2 more spectra of Sirius A.

The centre of the CCD is used in this case rather than the E1 aperture for 2 reasons.

- 1) It is recommended that the center of the CCD is used for bright targets to avoid serial transfer artifacts which can be caused by reading out the deeper wells at the E1 position.
- 2) The peakup is done at the centre position so doing the the science exposure at the same position is less likely to introduce inaccuracy in the target alignment in the slit.

The telescope will then be moved back to Sirius B to take a further 2 spectra. There is no time for a peakup but, as mentioned above, the small angle maneuver should be accurate enough.

The purpose of these last 2 Sirius B exposures is to provide a check for any changes over the course of the orbit.

We will take one spectrum at the 52x0.05 position for a direct comparison to the 2 Sirius A spectra that have just been taken. A final exposure at the E1 position will be taken to provide a direct comparison to the 2 Sirius B spectra taken at the start of the orbit.

Points to consider:

- 1) It is essential that no light from the bright Sirius A contaminates the spectrum of Sirius B.

For this reason we will use the narrow 52x0.05E1 slit which will minimise scattered light contamination.

- 2) ORIENT

It will be necessary to select an orientation for the telescope which will ensure that the slit does not include Sirius A when taking spectra of Sirius B. The orientation must also avoid placing Sirius B too close to the diffraction spikes from Sirius A.

- 3) The wavelength calibration must be as accurate as possible. The 52x0.05E1 slit provides the most precise wavelength measurements in the 6265A wavelength region.

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The placement of the target in the slit must be accurate to minimise the uncertainty in the wavelength zero point. We will use a pickup target acquisition to place the targets in the narrow slit accurately.

4) Extra wavecal exposures will be inserted throughout the orbit to monitor any changes to the wavelength calibration between the exposures for Sirius B and A.

5) The brightness of Sirius A means that the CCD becomes saturated even with the shortest possible exposure times (0.1 sec). Bohlin et al (2014) have made a similar observation of Sirius A using the 52x2 arc sec slit and 7 sub exposures of 0.3 seconds each. They have shown that the spectrum can be recovered even though it is saturated.

Scheduling:

The target co-ordinates provided are accurate for 5th Jan - 22nd Jan 2018.

We know the offset at a given date very precisely from the known binary orbit.

But the offset is continuously changing. Around the end of December, the separation increases by about 0.006 arcsec in 2 weeks, and the total offset changes by about 0.016 arcsec in 2 weeks.

For this reason we have limited the ORIENT range to a margin of +/-6 deg which allowed us to constrain the scheduling window to a 2 week period. The allowed margin in the ORIENT range can be increased to expand the scheduling window if it is not possible to schedule it in the available window. However, we would need to update the target position co-ordinates if the observation is scheduled outside the 5th-22nd Jan window.

Allowing the ORIENT range to vary by +/-12 degrees increases the possible scheduling window to 5-22nd Jan 2018 and 7th - 14th Feb 2018 and 12th Jan -14th Feb 2019

Proposal 15237 - Visit 01 - Resolving the discrepancy in the mass determination from the gravitational redshift of Sirius B

Fri Oct 20 00:00:21 GMT 2017

Visit	Proposal 15237, Visit 01, implementation Diagnostic Status: No Diagnostics Scientific Instruments: STIS/CCD Special Requirements: PCS MODE FINE; ORIENT 14.52D TO 38.52 D; ORIENT 200.52D TO 212.52 D					
	Patterns	#	Primary Pattern	Secondary Pattern	Exposures	
		(1)	Pattern Type=STIS-ALONG-SLIT Coordinate Frame=POS-TARG Purpose=DITHER Pattern Orientation=90.0 Number Of Points=2 Angle Between Sides= Point Spacing=0.40624 Center Pattern=true Line Spacing=		(3), (8)	
Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
	(1)	SIRIUS-B	RA: 06 45 8.7288 (101.2863700d) Dec: -16 43 17.40 (-16.72150d) Equinox: J2000	Proper Motion RA: -0.036595 sec of time/yr Proper Motion Dec: -0.9531 arcsec/yr Parallax: 0.379" Epoch of Position: 2018.0592	V=8.44	Reference Frame: ICRS
	<i>Comments: The RA and Dec of Sirius B are measured from WFC3 frames taken in 2016 October and corrected for parallax and proper motion to 2018.0592. The proper motion given here is the "effective" proper motion calculated by combining the Hipparcos motion of the center of mass of the Sirius system with the motion of Sirius B in the binary relative to the center of mass at an early 2018 epoch. Extended=NO</i>					
	(2)	SIRIUS-A	Offset from SIRIUS-B RA Offset: -0.724023 Secs Dec Offset: -3.4151 Arcsec		V=-1.47	Offset Position (SIRIUS-A)

Proposal 15237 - Visit 01 - Resolving the discrepancy in the mass determination from the gravitational redshift of Sirius B

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit	
Exposures	1	acquisition S irius B (STIS.ta.101 1194)	(1) SIRIUS-B STIS/CCD, ACQ, F28X50LP	MIRROR	ACQTYPE=POINT		Sequence 1-11 Non-Int in Visit 01	0.1 Secs (0.1 Secs) [==>]	[1]	
	2	peak up Siri us B (STIS.ta.101 2956)	(1) SIRIUS-B STIS/CCD, ACQ/PEAK, 31X0.05NDA	MIRROR			Sequence 1-11 Non-Int in Visit 01	0.1 Secs (0.1 Secs) [==>]	[1]	
	3	Sirius B spe c 1-2 (STIS.sp.10 11242)	(1) SIRIUS-B STIS/CCD, ACCUM, 52X0.05E1	G750M 6581 A			Sequence 1-11 Non-Int in Visit 01 Pattern 1, Exps 3-3 i n Sequence 1-11 No n-Int in Visit 01 (1)	100.0 Secs (200 Secs) [==>(Pattern 1, Split 1)] [==>(Pattern 1, Split 2)] [==>(Pattern 2, Split 1)] [==>(Pattern 2, Split 2)]	[1]	
	4	Sirius A spe c E1 (STIS.sp.10 11233)	(2) SIRIUS-A STIS/CCD, ACCUM, 52X0.05E1	G750M 6581 A	CR-SPLIT=2; GAIN=4		Sequence 1-11 Non-Int in Visit 01	0.2 Secs (0.2 Secs) [==>(Split 1)] [==>(Split 2)]	[1]	
	5	Sirius A spe c E1 (STIS.sp.10 11233)	(2) SIRIUS-A STIS/CCD, ACCUM, 52X0.05E1	G750M 6581 A	CR-SPLIT=2; GAIN=4		Sequence 1-11 Non-Int in Visit 01	0.2 Secs (0.2 Secs) [==>(Split 1)] [==>(Split 2)]	[1]	
	6	peakup Siriu s A (STIS.sp.10 12957)	(2) SIRIUS-A STIS/CCD, ACQ/PEAK, 31X0.05NDC	G750M 6581 A			Sequence 1-11 Non-Int in Visit 01	0.1 Secs (0.1 Secs) [==>]	[1]	
	7	wavecal	WAVE	STIS/CCD, ACCUM, 52X0.05	G750M 6581 A			Sequence 1-11 Non-Int in Visit 01	[==>]	[1]
	8	Sirius A spe c 1 (STIS.sp.10 12961)	(2) SIRIUS-A STIS/CCD, ACCUM, 52X0.05	G750M 6581 A	CR-SPLIT=3; GAIN=4		Sequence 1-11 Non-Int in Visit 01 Pattern 1, Exps 8-8 i n Sequence 1-11 No n-Int in Visit 01 (1)	0.9 Secs (1.8 Secs) [==>(Pattern 1, Split 1)] [==>(Pattern 1, Split 2)] [==>(Pattern 1, Split 3)] [==>(Pattern 2, Split 1)] [==>(Pattern 2, Split 2)] [==>(Pattern 2, Split 3)]	[1]	
	9	Sirius B spe c 3-4 (STIS.sp.10 11242)	(1) SIRIUS-B STIS/CCD, ACCUM, 52X0.05	G750M 6581 A	CR-SPLIT=NO		Sequence 1-11 Non-Int in Visit 01	75.0 Secs (75 Secs) [==>]	[1]	
	10	Sirius B spe c 3-4 (STIS.sp.10 11242)	(1) SIRIUS-B STIS/CCD, ACCUM, 52X0.05E1	G750M 6581 A	CR-SPLIT=NO		Sequence 1-11 Non-Int in Visit 01	75.0 Secs (75 Secs) [==>]	[1]	
	11	wavecal	WAVE	STIS/CCD, ACCUM, 52X0.05	G750M 6581 A			Sequence 1-11 Non-Int in Visit 01	[==>]	[1]

