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Wide-Field Variability Surveys: A 21st Century Perspective

Obtaining accurate radial velocities for Cepheid companions using the STIS echelles

C. R. Proffitt[1], *N. R.* Evans[2], *E. M.* Winston[2], *A.* Gallenne[3], and *P.* Kervella[4,5]

[1] *Space Telescope Science Institute, Baltimore, MD 21218, USA*
[2] *Smithsonian Astrophysical Observatory, MS 4, 60 Garden Street, Cambridge, MA 02138, USA*
[3] *European Southern Observatory, Alonso de Cordova 3107, Casilla 19001, Santiago 19, Chile*
[4] *LESIA, Obs. de Paris, CNRS UMR 8109, UPMC,Univ. Paris 7, 5 Pl. Jules Janssen, 92195 Meudon, France*
[5] *CNRS UMI 3386, Departamento de Astronomía, Universidad de Chile, Las Condes, Chile*

Abstract. We discuss the high dispersion echelle observations of the hot binary companions of six Cepheids with known radial-velocity orbits that we have obtained with the STIS FUV E140H mode on board the *Hubble Space Telescope*, with the goal of determining the masses of these Cepheids. We discuss the stability and repeatability of the STIS echelle wavelength scale and other issues that may limit the final accuracy of our mass determinations.

1 Introduction

Over the course of a number of recent *Hubble Space Telescope* (*HST*) GO programs we have obtained FUV echelle spectral observations with the Space Telescope Imaging Spectrograph (STIS) on board *HST* for a number of hot companions of binary Cepheid stars. Our goal is to determine the radial velocity amplitude of each companion's orbit and ultimately the mass of each Cepheid. Complementary observations to measure the astrometric orbit of each Cepheid are also underway, as detailed by the contributions of P. Kervella et al. & A. Gallenne et al. in these proceedings.

2 Wavelength stability and properties of individual companions

We have used the ISM lines superimposed on our spectra to demonstrate the stability of the wavelength scale over time (Fig. 1). These show that the wavelength scale is repeatable to about 0.25 km/s.

In Table 1 we list the approximate $T_{\rm eff}$, projected rotational velocity, $v \sin i$, and FUV flux estimated from our spectra, together with the orbital periods ([1]). For three stars $v \sin i$ is large and the broad lines may limit the obtainable RV accuracy. For two other systems the hot companions are also close binaries. This was known for SU Cyg ([2]) and the sharp lines of this star and the 6 epochs for which we have data may make it possible to solve for both the close and the wide orbit. The binary velocity of the AW Per companion (Fig. 2) confirms its previously suspected binary nature, but additional data are needed to constrain its short period orbit. AX Cir is a triple system, and the previous IUE observations were dominated by the brighter long period companion; this is the first spectrum obtained of the close 18 yr SB companion. Work is ongoing to derive the absolute velocities and stellar parameters, and these results will be used to determine the masses and evolutionary state for each system.

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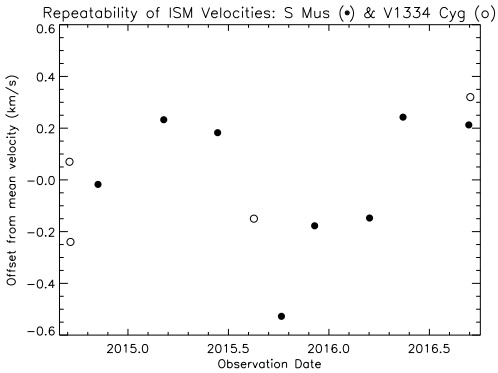

Figure 1. The measured offsets of the O I ISM line wavelength about the mean value measured in each star are shown for our observations of S Mus and V1334 Cyg. The rms scatter about the mean is equivalent to only 0.24 km/s. This demonstrates that the STIS echelle wavelength scale as determined using internal wavelength calibration observations is very stable and can be used to compare STIS observations taken months or years apart.

Table 1. Close Cepheid companions with STIS E140H observations.

Star	$P_{\rm orb}$ (yr)	$T_{\rm eff}$ (K)	$v \sin i$ (km/s)	$F_{1322} \times 10^{-14}$ (ergs cm^{-2}Å^{-1}s^{-1})	# epochs	Comments
V350 Sgr	4.0	10000	180	4.1	2	
SU Cyg	1.5	13250	< 3	160	8	close triple
S Mus	1.4	15000	20	550	8	
V1334 Cyg	5.3	13500	180	1100	3	
AX Cir	17.9	11000	180	88	1	wide triple
AW Per	36	15750	15	9.5	1	close triple

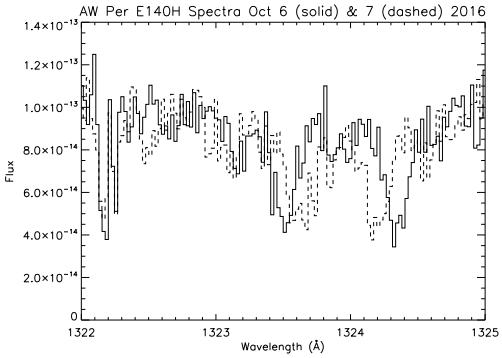

Figure 2. The C II multiplet near 1324 Å is doubled in the spectrum of AW Per and changes significantly in a single day, while the ISM CO line near 1322.2 Å is unchanged. This demonstrates that the hot companion is itself a close short period double-lined binary.

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