

From the first CCD measurements of double stars at Vidojevica towards speckleinterferometry

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FUTURE SCIENCE WITH METRE-CLASS TELESCOPES

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About the site



- Location:

- Vidojevica: longitude $21^{\circ} 33' 20''.4$
latitude $43^{\circ} 08' 24''.6$
- Altitude: 1150 m
- Average seeing: $\sim 1.5''$

and the telescope



- Telescope:
 - Cassegrain reflector
 - Primary mirror 60 cm
 - Focal length ≈ 600 cm

About the CCD cameras

- SBIG ST₁₀ME:

- Size of chip: 1.485cm x 1.026cm ,
2148pixel x 1472pixel
- Size of pixel: 6.8 μ x 6.8 μ
- Field of view: 8.51' x 5.88'
- Angle corresponding to one pixel:
0.23" x 0.23"

$$F_{10} = 5972 \pm 4 \text{ mm}$$



- Apogee Alta U42:

- Size of chip: 2.76cm x 2.76cm ,
2048pixel x 2048pixel
- Size of pixel: 13.5 μ x 13.5 μ
- Field of view: 15.81' x 15.81'
- Angle corresponding to one pixel:
0.46" x 0.46"

$$F_{42} = 5989 \pm 7 \text{ mm}$$

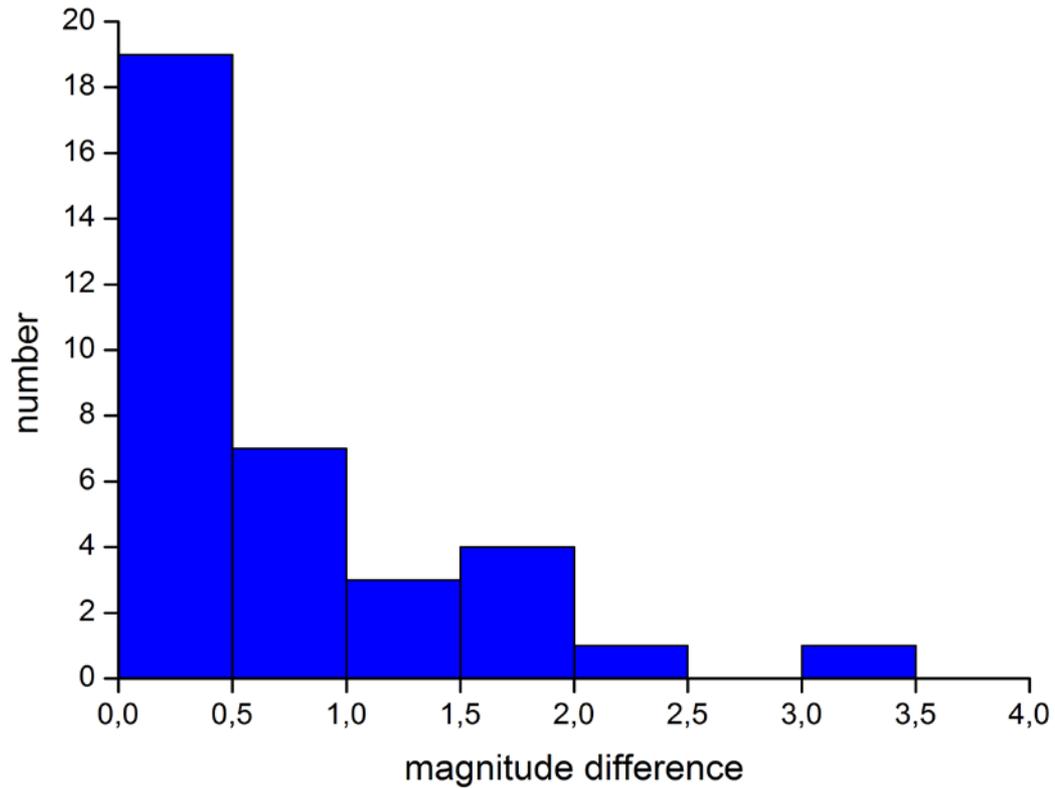


Observations

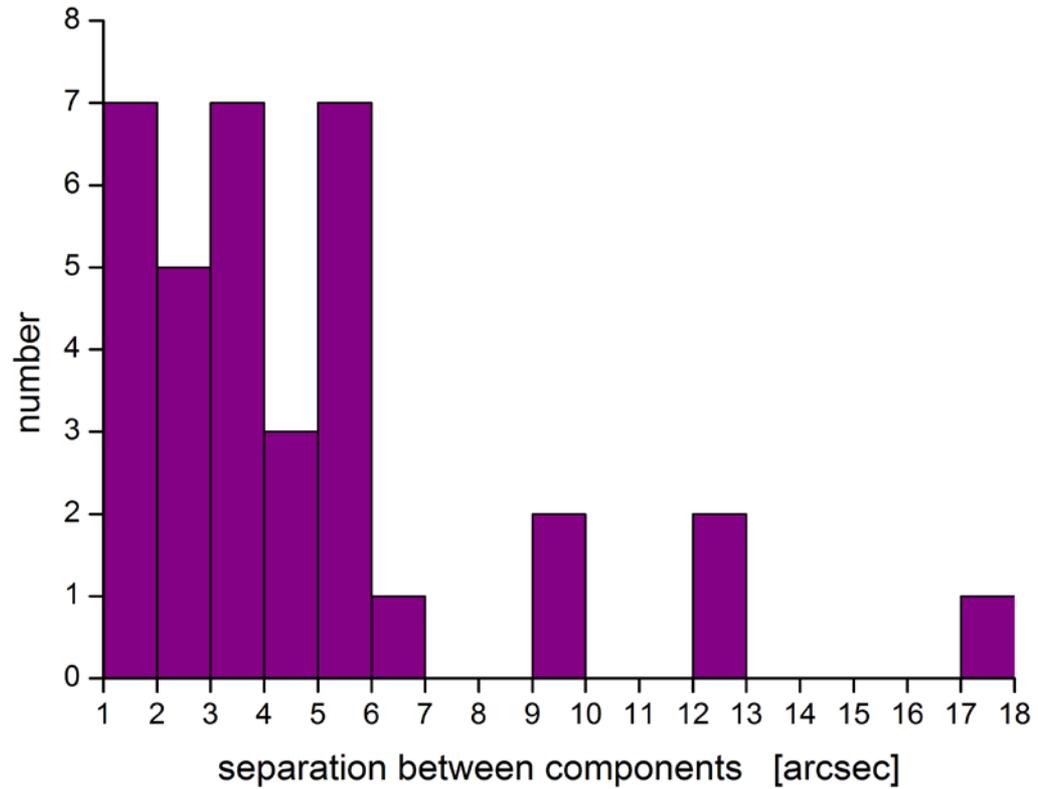
- First on 18/19.06.2011. using camera SBIG ST10ME - 15 double stars
- Second on 19/20.08.2011. using camera Apogee Alta U42 - 20 double stars
- Third on 20/21.10.2011. using camera Apogee Alta U42 - 58 double stars
- Fourth on 02-04.11.2011. using camera SBIG ST10ME - 114 double stars
- Fifth on 22/23.04.2012. using camera Apogee Alta U42 - 16 double stars
- Sixth on 21-24.06.2012. using camera Apogee Alta U42 - 101 double stars

Choosing stars

by magnitude difference



by separation



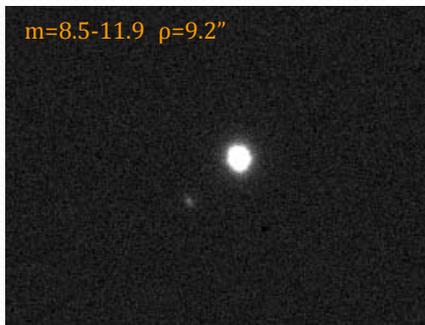
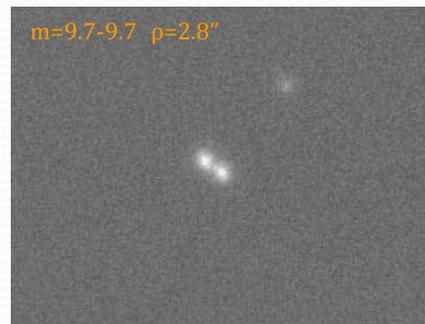
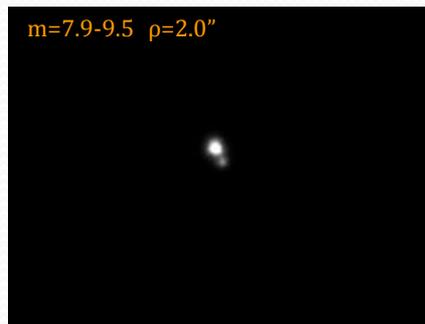
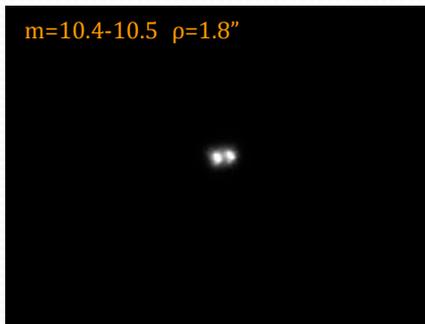
Reached minimal separation



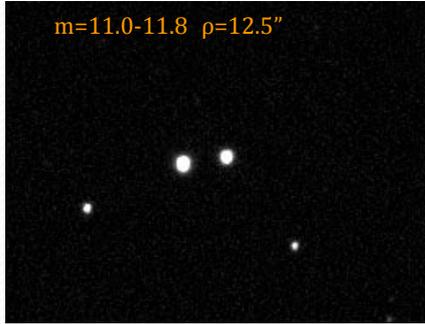
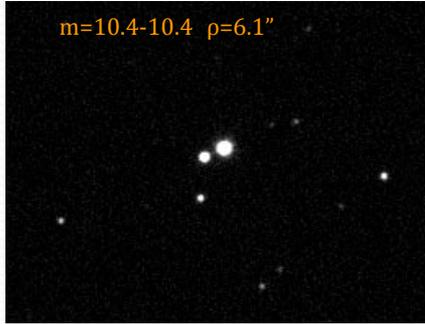
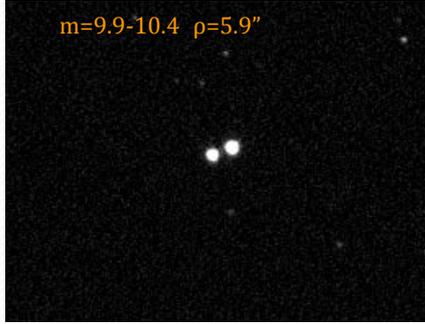
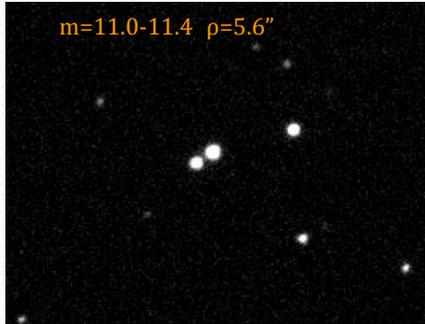
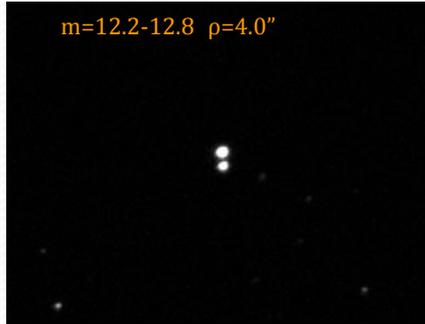
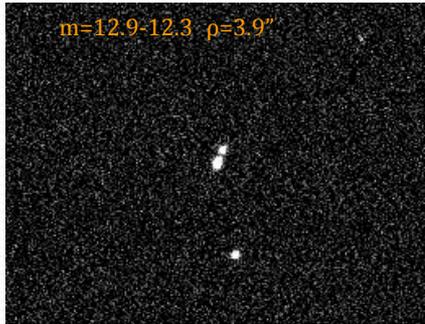
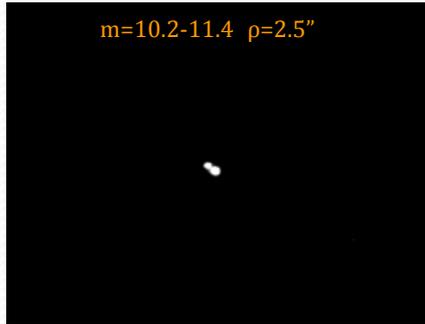
SBIG ST10ME



Apogee Alta U42



**CCD camera:
SBIG ST10ME**



CCD camera:
Apogee Alta U42

SYSTEM ADS 48: VISUAL BINARY OR MULTIPLE SYSTEM

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FOCAL LENGTH DETERMINATION FOR THE 60 cm TELESCOPE AT ASTRONOMICAL STATION VIDOJEVICA

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SUMMARY: The focal length of a telescope is an important parameter in determining the angular pixel size. This parameter is used for the purpose of determining the relative coordinates (angular separation and position angle) of double and multiple stars, and the precise coordinates of extragalactic radio sources (ERS) that are visible at optical wavelengths. At the Astronomical Station Vidojevica we have collected observations of these objects using two CCD cameras, Apogee Alta U42 and SBIG ST-10ME, attached to the 60 cm telescope. Its nominal focal length is 600 cm as given by the manufacturer. To determine the telescope focal length more precisely for both attached detectors, we used angular-separation measurements from CCD images taken at Astronomical Station Vidojevica. The obtained focal lengths are: $F_{42} = (5989 \pm 7)$ mm using the CCD camera Apogee Alta U42 attached to the telescope, and $F_{10} = (5972 \pm 4)$ mm with the CCD camera SBIG ST-10ME attached to the telescope.

Key words: method: observational – telescopes – instrumentation: detectors

INTRODUCTION

The telescope focal length is an important parameter in determining the angular pixel size. It is used for the purpose of determining the relative coordinates (angular separation and position angle) of double and multiple stars, as well as in determining the precise coordinates of radio sources.

In this paper we present the first results of determining the effective focal length of the new 60 cm telescope mounted at Astronomical Station Vidojevica (ASV) for two cameras. The Astronomical Station Vidojevica is located in southern Serbia on the mountain of Vidojevica with Prokuplje as the nearest town. The geographic coordinates of the station are: the longitude $21^{\circ} 33' 20''.4$, latitude $43^{\circ} 08' 24''.6$ and altitude of 1150 m above the sea level. More details can be found at <http://belisima.aob.rs/>.

EQUIPMENT AND METHOD

The 60 cm telescope was purchased from Astro Optik - German company which, in the meantime, became a part of a much bigger company Astro System Austria (ASA). The telescope has a German equatorial mount and a Cassegrain optical system with optical elements produced by the LOMO company in St. Petersburg, Russia. The primary mirror is parabolic with a mechanical diameter $D=60$ cm and $f/3$ focal ratio. The secondary mirror is hyperbolic with the diameter $D=20$ cm making a classical Cassegrain optical system (Fig. 1). Both mirrors are covered with a highly reflective AlSiO₂ coating. The telescope focal length is 600 cm with focal ratio of $f/10$ as given by the manufacturer. We have also provided one $f/6$ focal reducer with 4 lenses organized

ABSTRACT

In this paper, we analyze seven components of system ADS 48. Its number in the Washington Double Star Catalog is 00057+4549. We use the measuring results from our CCD frames obtained between 1994 and 2011. Our aim is to establish which of these components are gravitationally bound, i.e., have an orbital motion around the mass center, and which of them are mutually very distant in space so that only their projections are close in the field of view. In addition to the measurements, we also apply different criteria based on celestial mechanics. Out of seven considered components, only the closest pair STT 547 AB is in orbital motion around the mass center. The other components, except that with the largest separation, are merely projected stars. The most distant component has common proper motion with pair AB.

Key words: binaries: visual – stars: individual (ADS 48) – techniques: image processing

1. INTRODUCTION

Systematic observations of double stars have been carried out for about 200 years. The measuring techniques and methods have been inevitably changed and improved, from visual micrometric measurements toward high-angular-resolution techniques. The Washington Double Star Catalog (WDS)¹ contains the data for more than 117,000 pairs, components of double or multiple stars, for which the relative coordinates, position angle, and angular separation have been measured. Out of this number, almost 102,000 pairs have been observed less than 10 times. Also, in the case of many pairs no change in position angle and/or angular separation over a sufficiently long time interval has been registered. Only for a small number of pairs, about 2100, have the orbital elements been calculated, i.e., a Keplerian motion has been confirmed. Their orbital elements can be found in the Sixth Catalog of Orbits of Visual Binary Stars.² This is about 2% of the whole sample. In the case of more than 1200 pairs there are linear solutions given in the Catalog of Rectilinear Elements.³ In the case of such pairs there are, in principle, three possibilities: to be gravitationally bound, but with large orbital periods, to be kinematically similar (say, common-proper-motion pairs), and to be mere optical pairs. For the purpose of establishing which of the three possibilities is the true one, observations covering long time intervals or detailed analysis of their data are needed.

An example of interest is a system registered in ADS—the Aitken Double Stars catalog (Aitken 1932)—as ADS 48. In WDS its number is 00057+4549 and there are measured relative coordinates between eleven components. The closest pair was discovered by O. Struve in 1876 (Struve 1878) and its designation is STT 547 AB after him. Up to now this pair has been measured 394 times. R. Furuhielm in 1897, as cited in ADS, made the first measurement for the pair designated in WDS as STT 547 AF. In the early twentieth century S. W. Burnham in 1911 (Burnham 1913) made the first measurements for other three pairs in WDS designated as STT 547 AC, STT 547 AD, and STT 547 AE. The relative coordinates for these pairs have been measured from that time. The number of measurements for them are 10, 17, 23, and 36, respectively. The seventh com-

ponent P was discovered by G. Popović in 1994 (Popović & Pavlović 1997a) and 16 measurements for the pair designated as POP 217 AP are available. In the case of four other pairs of this system—POP 217 AQ, POP 217 AX, POP 217 AY, and POP 217 YG—the number of measurements is small (less than 10). They were observed within a short time interval between 1998 and 2006. The magnitude differences between the components for these four pairs are large ($\Delta m > 5$), the components Q, X, Y, and G are fainter than $m = 14$. They are not considered here. The complete measurements for this system were obtained from the Washington Database due to the courtesy of B. Mason to whom we owe our very sincere gratitude.

Until now the orbits for the closest pair AB and the widest pair AF have been calculated. In the Sixth Catalog of Orbits of Visual Binary Stars, one can find two orbital solutions concerning AB: Popović & Pavlović (1996) and Kiyava et al. (2001). In the case of AF preliminary orbital elements have been given by Kiyava et al. (2001). The motion of the F component has been measured since 1897 and in the course of these 115 years neither its position angle nor the angular separation have changed. In almost all of the measurements the photographic method was applied, with an astrograph (Kiyava et al. 2001). The orbital period has been estimated to be 830 centuries. For the other four pairs—AC (Friedman et al. 2012), AE (Hartkopf & Mason 2011), and AD and AP (Cvetković 2011)—linear solutions have been determined and one can find them in the Catalog of Rectilinear Elements.

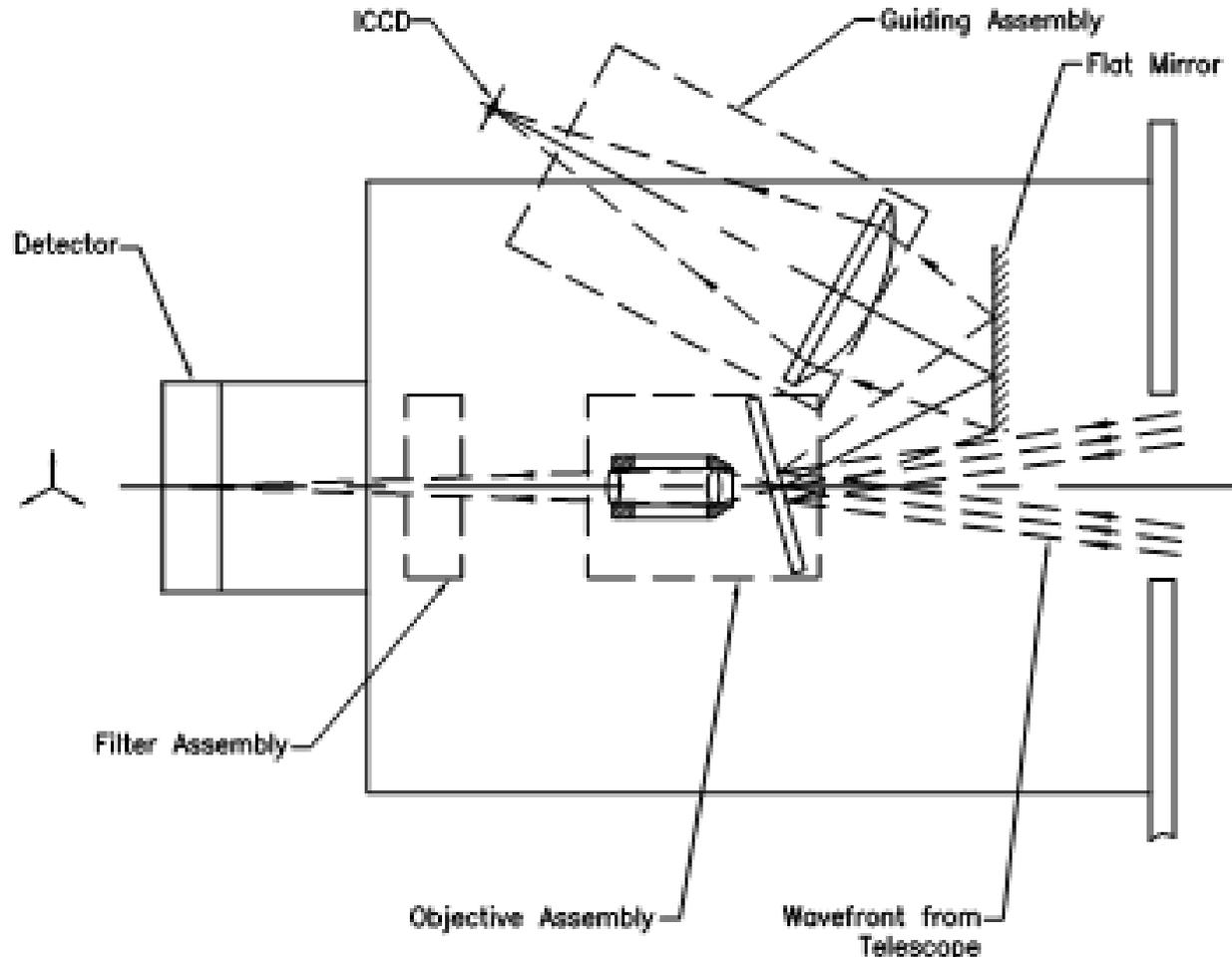
In the present paper we want to examine the components of system ADS 48 listed in WDS, more precisely to establish if any of them together with the closest pair AB forms a gravitationally bound system. Such an analysis also includes the possibility of common kinematics.

2. OBSERVATIONS

From 2004 till now a group of astronomers from the Belgrade Observatory have stayed several times at the National Astronomical Observatory Rozhen (NAOR) in Bulgaria and taken frames of visual double and multiple stars. A series of observations of double and multiple stars at the Bulgarian NAOR have been made with a CCD camera attached to their 2 m telescope. Only in the observations from 2004 was the CCD camera Photometrics CE200A used. The chip dimensions are 1024×1024 pixels, and the pixel size is $24 \mu\text{m} \times 24 \mu\text{m}$.

¹ <http://www.usno.navy.mil/USNO/astronomy/optical-IR-prod/wds/WDS>
² <http://www.usno.navy.mil/USNO/astronomy/optical-IR-prod/wds/orb6>
³ <http://www.usno.navy.mil/USNO/astronomy/optical-IR-prod/wds/lin1>

Near future - speckle interferometry



Optical layout of the speckle interferometer (Saha et al. 1999)

How to spend 50,000 €?





Thank you for your attention!