

COMMISSION 26

DOUBLE AND MULTIPLE STARS

ETOILES DOUBLE ET MULTIPLE

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TRIENNIAL REPORT 2009-2012

1. H. Abt, NOAO

Main Publications:

Abt, H. A. 2008, The Difference Between Metal-Poor and Metal-Rich Binaries, *AJ*, 135, 722

Abt, H. A. 2009, Stellar Rotation versus Duplicity in Open Cluster Early-Type Stars, *PASP*, 121, 1307

Abt, H. A. 2010, The Origin of the Exoplanets, *PASP*, 122, 1015

Abt also gave invited talks in the workshops held in Santiago de Compostela: Double and Multiple Stars: Dynamics, Physics, and Instrumentation. December 10-11, 2009. “The Nature of Exoplanets”.

Binaries Inside and Outside the Local Interstellar Bubble. February 10-11, 2011. “The age of the Local Interstellar Bubble”.

2. David Dunham, President, International Occultation Timing Association

In 2008, the International Occultation Timing Association (IOTA) took over the role of collecting, analyzing, and archiving all observations of lunar occultations from the International Lunar Occultation Centre (ILOC) in Japan. In the course of our work, many close double stars were discovered, and other known close binaries measured. Recent Publications: Herald, D., Dunham, D., *et al.*, “New Double Stars from Asteroidal Occultations, 1971-2008”, *Journal of Double Star Observations*, Vol. 6, No. 1, pp. 88-96, 2010. Loader, B., *et al.*, “Lunar Occultation Observations of Known Double Stars - Report #1”, *Journal of Double Star Observations*, Vol. 6, No. 3, pp. 176-179, 2010.

3. Z.Cvetković, Astronomical Observatory of Belgrade

Serbian astronomers have performed three series of CCD observations of visual double and multiple stars at the NAO Rozhen from 2009 to 2011. A total of 237 pairs were measured and the results were published in Cvetković *et al.* (*) and Cvetković *et al.* (+). Z.Cvetković announced 25 new/recalculated orbits and 3 linear solutions in Circulars IAU Commission 26 :

Circ. 167 - 7 orbits; Circ. 169 - 2 orbits; Circ. 170 - 6 orbits; Circ. 172 - 4 orbits; Circ. 174 - 6 orbits and 3 linear solutions.

We have started CCD observations of visual double and multiple stars at the Astronomical Station on the mountain of Vidojevica (South Serbia) with a 60 cm telescope.

Articles published in 2009-11: Publ. Astron. Obs. Belgrade: 2 articles in 2009 and 1 article in 2010. (*) Serbian Astronomical Journal: 3 articles in 2010. (+) Astronomical Journal: 1 article in 2010 and 2 in 2011. Astronomische Nachrichten: 1 article in 2010. New Astronomy: 1 article in 2010. Publ. of the Astronomical Society RudjerBokovic: 1 article in 2009.

4. P. Lampens, Royal Observatory of Belgium

Main Research lines and corresponding publications:

4.1. A.1. Visual Binaries:

Torres, K.B.V., *et al.* (2011) Spectra disentangling applied to the Hyades binary Theta² Tauri AB: new orbit, orbital parallax and component properties. A&A, 525, 50

4.2. A.2. Eclipsing Binaries:

Desmet, M., *et al.* (2010). Combined modelling of the interacting eclipsing binary AU Mon based on CoRoT and ground-based photometry and high-resolution spectroscopy MNRAS, 401, 418.

Lampens, P., *et al.* (2010) New Times of Minima of 36 Eclipsing Binary Systems Information Bulletin on Variable Stars, 5933, 1

Borkovits, T., *et al.* (2008) New and Archive Times of Minima of Eclipsing Binary Systems. Information Bulletin on Variable Stars, 5835, 1.

Wils, P., Lampens, P., Van Cauteren, P., Southworth, J. (2010). The Highly Active Low-Mass Eclipsing Binary BS Uma Information Bulletin on Variable Stars, 5940, 1

Ulas, B., Niarchos, P.G., Lampens, P., Liakos, A. The Algol-type eclipsing binaries RW CrB and VZ Leo: new RI photometric study and search for pulsations 2009, ApSS 319, 55

Rodriguez, E., *et al.* (2010) Delta Scuti-type pulsations in eclipsing binary systems: Y Cam MNRAS, 408, 2149

Hambusch, F.-J., *et al.* (2010) Detection of a Rapidly Pulsating Component in the Algol-Type Eclipsing Binary YY Boo Information Bulletin on Variable Stars, 5949, 1

Lampens, P., *et al.* (2011) Multi-site, multi-year monitoring of the oscillating Algol-type binary CT Her, A&A, 534, 111

5. V. Orlov, Astronomy Department, Saint Petersburg University, Russia

Research in progress and some relevant results:

1. Dynamics of multiple stars can reflect some features of star formation and following dynamical evolution of stellar groups. We consider multiple stars in the solar

neighbourhood using by the catalog MSC (Multiple Star Catalogue). We have selected the systems which are near the stability boundary. These systems may be dynamically (sometimes physically) young. We discuss some hypotheses of origin of such systems and propose future observations for a number of systems in order to make more accurate some critical data.

2. Some physical and dynamical parameters of the multiple system HD 222326 are presented.

We suggest a new method for determination of individual radial velocities of wide binaries components, when difference of radial velocities is small.

3. The analysis of physical parameters, orbital elements, and dynamical stability for the multiple star HD 76644 is presented. The data of astrometric observations from the WDS Catalogue and original observations taken with the BTA 6-m Telescope of Special Astrophysical Observatory of the Russian Academy of Sciences and the RTT150 1.5-m Telescope at Tubitak National Observatory, Turkey, were used.

4. An analysis of the physical characteristics, orbital parameters, and dynamical stability of the multiple Be star HD 217675 (α And) is presented.

5. Criteria for stability of triple systems are studied and compared with the results of numerical simulations obtained for model triple systems and observed multiple stars. The results for the stability analyses using two new criteria - those of Aarseth and of Valtonen et al. - agree with the simulation results in 98% of cases. The last published version of the "Multiple-Star Catalog" of Tokovinin is analyzed to search for systems that may be unstable according to the two new criteria. More detailed studies are carried out for the HD 284419 (T Tau) system.

6. Oswalt and collaborators, Florida Institute of Technology.

Oswalt and collaborators Zhao and Holberg have been using fragile binaries to investigate several astrophysical problems.

Publications: 1) Johnston, K., Oswalt, T., Valls-Gabaud, D. 2011, "Orbital Separation Amplification in Fragile Binaries with Evolved Components," *New Astronomy*, accepted. 2) Zhao, J.K., Oswalt, T.D., Rudkin, M., Zhao, G., Chen, Y.Q., 2011, "The Chromospheric Activity, Age, Metallicity and Space Motions of 36 Wide Binaries", *AJ* 141, 107. 3) Zhao, J.K., Oswalt, T.D., Zhao, G. 2011, "Fragile Binary Candidates in the SDSS DR8 Spectroscopic Archive", *AJ*, accepted 11/8/11, 2011arXiv1111.2831Z.

Manuscripts submitted:

1) Holberg, J.D. Oswalt, T.D., Barstow, M. 2011, "Observational Constraints on the Degenerate Mass-Radius Relation", submitted to *AJ* 11/2/11.

2) Zhao, J.K., Oswalt, T.D., Willson, L.A., Wang, Q., Zhao, G., 2011, "The Initial-Final Mass Relation among White Dwarfs in Wide Binaries", *ApJ*, submitted.

7. PISCO Group

M. Scardia and L. Pansechi, INAF-Merate Observatory, Italy J.-L. Prieur, CNRS-Toulouse University, France R.W. Argyle, Cambridge Observatory, U.K.

During the period 2009-2011, we continued our speckle observation program of visual binaries with PISCO in Merate. The total number of measurements made since 2004 now

exceeds 2300. Optical tests of the telescope were also done after this operation. We added a 32 mm eyepiece in the magnification wheel of PISCO. This allowed a new observing mode with a low magnification which increased the sensitivity. We are thus now able to observe 11th magnitude binaries when their separation is larger than 0.9 arcsec. In 2010 we started a collaboration with René Gili in Nice who observes visual binaries with the historical 74 cm refractor. A new speckle camera called PISCO2 was made in 2010 for this telescope. It is a simplified version of PISCO with the same optical concept.

Publications in refereed journals in 2009-2011:

- Scardia, M., *et al.*, 2009, *Astron. Nach.*, 330, 55-67
 Prieur, J.-L., *et al.*, 2009, *MNRAS*, 395, 907-917
 Scardia, M., *et al.*, 2010, *Astron. Nach.*, 331, 286-299
 Prieur, J.-L., *et al.*, 2010, *MNRAS*, 407, 1913-1925
 Scardia, M., *et al.*, 2011, *Astron. Nach.*, 332, 508-523

Other publications in 2009-2011

- Argyle R.W., Scardia M., Prieur J.-L., Pansecchi L., 2009, Double and Multiple Stars: Dynamics, Physics, and Instrumentation, held 10-11 December 2009, in Santiago de Compostela (Spain) Eds: J.A. Docobo, V.S. Tamazian, Y.Y. Balega 2011, AIP Conf. Proc. 1346, 42-56
 Argyle R.W., Scardia M., Prieur J.-L., Pansecchi L., 2010, Annual Meeting of the Royal Astronomical Society, held January 2010, in London (U.K.) Published in 2010, The Observatory, Vol 130, No 1217, pp 200-202
 Scardia, M.; Prieur, J.-L.; Pansecchi, L.; Argyle, R. W. 15 orbits published in the Information Circulars n. 167, 168, 169, 170, 171 and 172.

8. The Main (Pulkovo) Astronomical Observatory of Russian Academy of Sciences

Our team works in the Laboratory of Astrometry and Stellar Astronomy at The Main (Pulkovo) Astronomical Observatory of Russian Academy of Sciences. The observations of double stars have been continued in this period by means of the 26-inch Pulkovo observatory refractor. The results of observations are published on the Pulkovo site: <http://puldb.ru>.

Now we have 420 stars in the Pulkovo program. For more than 80 pairs there are the large series of observations since 1960 to 2005 years.

Publications:

- N.A.Shakht, A.A.Kiselev, *Planetary Space Sciences* 2478, v.56, issue 14, p.p. 1903-1907, 2008.
 N.A.Shakht, *et al.*, *Astrofizika (Journal of Armenian Academy of Sciences)*, v.53, No 2, p. 257-267, 2010 (in Russian), also in *Astrophysics*, v.53, No2, 2010, (in English) *STELLAR SPECTRA* 5
 V.A.Zakhodzha, Yu.N.Gnedin, N.A.Shakht, *Astrophysics* v.53, N0 4, p.p.575-591, 2010.
 N.A.Shakht, A.A.Kiselev, I.G.Romanenko, E.A.Grosheva. *Isvestia GAO* No 219. v. 4, p.p. 375-380, 2010 (in Russian).
 Kiselev A.A., Romanenko L.G., Kalinichenko O. A., *Astronomy Reports*. v. 53. no. 2. p. 126-135, 2009.

Kiselev A.A., Romanenko L.G. and Gorynya N.A. *Astronomy Reports*. v. 53. no. 12. p. 1136-1145, 2009.

Kiselev A.A. and Romanenko L.G. *Astronomy Reports*. v. 55. n 6. p. 487- 496, 2011.

Conference presentations:

A. A. Kiselev, N. A. Shakht, E. A. Grosheva, L. G. Romanenko. Proc. of the Meeting "Earth Based Support to Gaia Solar system science, Beaulieu sur Mer, 27-28 Oct. 2008."

N. A. Shakht, E. A. Grosheva, D. L. Gorshanov, A. A. Kiselev, E. V. Polyakov, O. O. Vasil'kova. In Workshop "Astrometry now and in the future", Antalya, Turkey, September 12-13, 2011.

9. Ramon Maria Aller Astronomical Observatory (OARMA), Santiago de Compostela, Spain

9.1. *Research Projects.*

The main line of research at OARMA concerns binary and multiple stars. The Spanish Ministry of Research and Innovation supported our investigation during the past years through the following projects: Speckle interferometry, differential photometry, spectroscopy and fundamental astrophysical parameters of double and multiple stars (2008-2010); High precision astrometry and fundamental parameters of double and multiple stars (2011). Both were directed by Prof. J. A. Docobo. The research team was formed by J. A. Docobo, V. S. Tamazian, J. F. Ling, Y. Balega, N. Melikian, M. Andrade, J. F. Lahulla, I. Fernández, P. Campo. Information Circular IAU Comm. 26 (J. A. Docobo and J. F. Ling, eds.). From October 2008 to June 2011, 9 Information Circulars were published corresponding to Issues 166 to 174.

New orbits announced:

A total of 281 new orbits were announced in the Circulars, 140 of these belonging to stars of the Northern hemisphere and 141 to the Southern.

The following list shows the author(s) who announced them, together with the number of orbits contributed by each: Alzner-Argyle (5), Argyle-Alzner (1), Alzner-Argyle-Anton (1), Cvetković (28), Docobo (1), Docobo-Andrade (6), Docobo-Campo (6), Docobo-Ling (19), Docobo-Tamazian (14), Docobo-Tamazian-Kraus-Weigelt (1), Gili (1), Hartkopf-Mason (72), Mason (1), Mason-Hartkopf (40), Ling (14), Rica (9), Rica-Zirm (3), Roberts-Hartkopf (1), Roberts-Mason (1), Scardia-Prieur-Pansecchi-Argyle (19), Zirm (35), Zirm-Rica (3).

The circulars also include different information such as: new double stars, announcements, list of papers published on double and multiple stars, obituaries and notes. The Double Star Orbit Catalog (J. A. Docobo, J. F. Ling, P. Campo).

We have maintained our own Double Star Catalog which was updated on September 23, 2011. We believe that this Catalog complements the USNO Catalog. Currently, 2151 orbits of 1701 binaries are included in it. The Catalog can be checked online at the following link: <http://www.usc.es/astro/catalog.htm>.

Publications in Journals (2009-11).

Docobo, J. A.; Ling, J. F. *The Astronomical Journal*, Volume 138, Issue 4, pp. 1159-1170 (2009). Kraus, S.; *et al.* *Astronomy and Astrophysics*, Volume 497, Issue 1, 2009,

pp. 195-207. Docobo, J. A.; Tamazian, V. S.; Balega, Y. Y.; Melikian, N. D. *The Astronomical Journal*, Volume 140, Issue 4, pp. 1078-1083 (2010).
 Melikian, N. D.; *et al.* *Astrophysics*, Volume 53, Issue 3, pp.373-386 (2010).
 Melikian, N. D.; *et al.* *Astrophysics*, Volume 53, Issue 2, pp.202-211 (2010).
 Melikian, N. D.; *et al.* *Astrophysics*, Volume 54, Issue 2, pp.203-213 (2011).
 M. Andrade and J. A. Docobo. *ICARUS*: 2011, vol 215. Issue 2; 712-720 (2011).

Workshop Organization (J. A. Docobo, chairman; V. S. Tamazian, secretary).
 In the last three years, the OARMA organized two international workshops on binaries in Santiago de Compostela (Spain).
 Double and Multiple Stars: Dynamics, Physics, and Instrumentation. December 10-11, 2009. The proceedings were published by the AIP Series (AIP Conference Proceedings 1346. Ed. J. A. Docobo, V. S. Tamazian, Y. Y. Balega. ISBN 978-0-7354-0902-6. 2011).
 Binaries Inside and Outside the Local Interstellar Bubble. February 10-11, 2011. The proceedings will be published in AIP also. Other Research Activities.
 In this period, OARMA signed collaboration agreements with the Special Astrophysical Observatory (SAO) and the Byurakan Astrophysical Observatory (BAO), including observation runs. In 2011, our EMCCD speckle camera was sent to the BAO in order to attach it to their 2.6 m telescope as stipulated in our agreement.

10. Laszlo Szabados, Konkoly Observatory, Budapest, Hungary

Main Research lines and corresponding publications:
 Szabados, L., Kiss, Z. T., & Klagyivik, P. Binarity and Cluster Membership of Classical Cepheids. *EAS Publications Series*, Volume 45, 2011, pp.441-444.
 Szabados, L. Type II Cepheid. *Variable Stars, the Galactic halo and Galaxy Formation*, Eds. C. Sterken, N. Samus & L. Szabados. Sternberg Astronomical Institute of Moscow University, Russia. 2010.
 Csizmadia, Sz., Borkovits, T., Paragi, Zs. *et al.* Interferometric Observations of the Hierarchical Triple System Algol. 2009, *ApJ*, 705, 436 Klagyivik, P. & Szabados, L. Observational studies of Cepheid amplitudes. I. Period-amplitude relationships for Galactic Cepheids and interrelation of amplitudes. 2009, *A&A*, 504, 959.

11. US Naval Observatory

As of 1 October 2011 the repository of double star observations for Commission 26 (1964; *Transactions of the IAU*, Vol. 12B, 267; 1966), the Washington Double Star (WDS) Catalog, contained 817,749 means of 115,524 pairs. This represents an increase of 52,851 mean positions and 10,364 new pairs over the triennium. The most common means of WDS access other than the US Naval Observatory (USNO) website is the b/wds catalog on Vizier which can be utilized as an overlay in Aladin.
 Those systems with more complete kinematic solutions can be found in the Sixth Catalog of Orbits of Visual Binary Stars (2,236 orbits of 2,127 systems) and the Catalog of Rectilinear Elements (1,267 linear solutions to optical pairs or long-period physical systems). Similar growth to that of the WDS was seen in these two catalogs, as well as the Third Photometric Magnitude Difference Catalog and the Fourth Catalog of Interferometric Measurements of Binary Stars, all of which are maintained at the USNO and represent

the suite of catalogs considered part of the WDS ensemble.

The primary double star observational technique used by the USNO continues to be speckle interferometry. Our primary speckle camera was used on the twin 4m NOAO telescopes at Cerro Tololo and Kitt Peak, as well as the 61in telescope of the USNO Flagstaff Station. In collaboration with Andrei Tokovinin we have also used HRCam on the SOAR 4.1m telescope in Chile. We also maintain a less complex secondary camera for use on the USNO 26in refractor in Washington. Over the triennium, 1,064 observations of astrophysically interesting systems have been obtained and published with large telescopes and 3,410 systems, mostly neglected pairs or service observing, have similarly been obtained and published with the secondary camera.

José A. Docobo

president of the Commission president of the Commission