International Meeting on Eclipsing Binary Star Systems (EBS)

November 11 and 12, 2023
Paris, France

Organized by:
Société Astronomique de France (SAF), Double Stars Committee
Binary Systems of South and North (BSN) Project

Scientific Organization Committee
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-Filiz Kahraman Alicavus (Çanakkale Onsekiz Mart University, Türkiye)
-Amit Kashi (Ariel University, Israel)
-Rosa Poggiani (Pisa University, Italy)

Local Organization Committee
-Patrick Wullaert (Société astronomique de France, France) - Chair
-Pierre Palat (Société astronomique de France, France)

Website: Ameneh Shadlo

Venue
Meeting will be held at:
Société Astronomique de France (SAF)
3 rue Beethoven
75016 Paris - France
Tel.: 00 (33) 1 42 24 13 74
https://saf-astronomie.fr/
https://bsnp.info/EBS-International-Meeting

ABSTRACT BOOK

Accepted Oral Presentations

A New Tool for Light Curve Analysis of Binary Systems with a Fast MCMC Process

Ehsan Paki[1,2], Soroush Sarabi[1], Atila Poro[1,2], Ameneh Shadlo[1]
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The investigation of eclipsing binary systems, especially regarding characteristics such as mass ratio, star temperature, inclination, etc., depends on a proper and correct light curve analysis. This specification will lead us to the absolute parameters of a system. Various tools have been used so far for this purpose. The BSN project and Raderon Lab have presented a new tool with interesting capabilities for light curve analysis of binary systems. This new tool has been tried to provide all the necessary facilities to the user along with easier and more representative use. Also, the Markov chain Monte Carlo (MCMC) panel provides the possibility of analysis at a very high speed. This tool will be unveiled in this meeting, which in its trial version focused on contact binary systems.

Eclipses and Accretion in Massive Binary Stars

Amit Kashi[1]

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The evolution of very massive stars is significantly different from that of low-mass stars and involves physical processes rarely observed in low-mass stars. Most notably, these stars can exhibit strong instabilities that generate intense, clumpy winds and eruptive outbursts almost as luminous as core-collapse supernovae. I will discuss different stages of massive star evolution (Wolf-Rayet stars, B[e] Supergiants, Yellow Supergiants, Luminous Blue Variables, etc.), current understanding derived from theory and observations, and the remaining open questions in the field.

I will discuss these massive stars in binary systems. When present in a binary system, their winds collide and emit radiation across the spectrum, providing an opportunity to study the stars and their interactions. The shape of the colliding wind structure depends on the relative intensity of the winds and the orbital motion, making it time-dependent, thus affecting its emission.

I will discuss binary systems that show eclipses of two kinds - real eclipses as stars pass in front of each other, and artificial eclipses where accretion onto one of the stars changes the luminosity. The colliding wind problem involves multiple physical effects, necessitating 3D numerical simulations to capture its complexity. I will present simulations of colliding winds in massive binary systems, incorporating detailed treatments of wind ejection, orbital motion, clumpiness, and other effects. Furthermore, I will discuss conditions that may lead to accretion onto the star with the weaker wind and provide examples of systems where such accretion has been observed.

Gravitational Wave Emission of W UMa Stars

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The direct detection of gravitational waves has triggered an interest in gravitational wave sources over all frequencies.
Eclipsing binaries, including W UMa systems, are binary sources whose expected emission is in the low frequency band. I will present an estimation of the gravitational wave emission of W UMa systems in relation to the expected sensitivities of the forthcoming instruments.

Observing High Magnitude Binaries with Small Telescopes

Sabrina Baudart[1,2]
[1]Société astronomique de France, Paris, France
[2]Binary Systems of South and North (BSN) Project

The aim of this presentation is to show that, even with modest amateur equipment, it is possible to contribute to scientific research by observing binary systems up to magnitude 15.
I'll explain what a valid observation is through a few definitions of simple principles such as the signal-to-noise ratio or uncertainty in magnitude.
I'll present my equipment and the steps I take to obtain usable observations by adjusting parameters such as gain or exposure time. In support of my remarks, I'll refer to the article published last July on the first photometric study of the contact binary system CSS J003106.8+313347, to which I contributed with data I sent to the BSN project.

The Investigation of Extremely Low Mass Ratio Contact Binaries

Kai LI[1]

[1]Shandong University, Weihai, China

Estimations by Kochanek et al. (2014) suggested that the stellar merging event happens roughly once every 10 yr in our Galaxy. However, only one confirmed contact binary merging event has been observed up to now; that is, V1309 Sco (Tylenda et al. 2011). Theoretical studies have proposed that contact binaries exhibit a low mass ratio cutoff and will merge into fast-rotating single star due to the Darwin instability (e.g., Rasio 1995; Li & Zhang 2006; Arbutina 2007, 2009; Jiang et al. 2010; Wadhwa et al. 2021). The research on contact binaries with extremely low mass ratios is very essential to our understanding of the merging process and the low-mass ratio limit. This talk will present the investigation of extremely low mass ratio contact binaries carried out by our research group during the recent years.

Measurements of the Forgotten Eclipsing Binary IT HER

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[2]Binary Systems of South and North (BSN) Project
[3]American Association of Variable Star Observers

During July 2022 and July 2023, with Martine Castets (Association T60, Urania 31) we carried out a mission at the new 50cm telescope (replacing the venerable T60) at the Pic du Midi Observatory in France to obtain the light curves of the IT HER eclipsing binary. Jean-Bruno DESROSIERS (Mont Joseph Observatory - Quebec) then joined us to provide additional data. The presentation will briefly describe the means of observation as well as the results obtained and the questions still unanswered.

Automated Pipeline for a Forced, Multi-Aperture Photometry: Amateur Astronomy in the GAIA Era

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The GAIA satellite detected and measured the position and mean photometry of more than 1.8 billion stars in the Milky Way. One of the considerable progress enabled by this mission is about stellar variability. Indeed, the GAIA DR3 part. 4 catalog contains nearly 10 million variable objects [1], with 2.1 million for eclipsing binaries (EB) only (2), while the Variable Star Index (VSX) catalog contains 2.2 +-0.1 million sources, all types of variable stars included.
Faced with such a large number of EB targets, it is a complicated task to follow them up, find new exotic behaviors, high priority targets and characterize them all precisely with a high time resolution. This is a long term and exciting challenge in which the amateur astronomer community has all its role to play.
Amateur astronomers can image deep sky objects for several hours, in several large band filters and can obtain well pre-processed, aligned images. The frontier between photometry and photography appears when the data are modified to make faint structures more contrasted. However, pre-processed and aligned individual images can be useful high time resolution photometric data. With the large quantity of EBs ranging from magnitudes 3 to 21 [2], one amateur astronomer can almost be certain to detain from one to several hundreds of detectable EB stars in their images, depending on the field of view and limiting magnitude of their instrumental set up.
In this presentation, I will describe the Multi-Aperture Forced-Photometry automated pipeline and its associated protocol, developed at the Baronnies Provençales Observatory, which allows astrophotographers to automatically extract light curves of GAIA DR3 known eclipsing binaries from their images. I will discuss the potential of amateur's data as well and what we can expect from their quality based on a test case.
In the frame of a citizen science project, this tool has high pedagogical and scientific potentials. The aim of this presentation is also to start a discussion between several actors of the professional and amateur communities on how to organize such an effort.

[1] Eyer, L., et al.: A&A 674, A13 (2023)
[2] Mowlavi, N., et al., A&A 674, A16 (2023)

Effect of the Binary Star at the Center of Reflection Nebula

Prahladsinh Jadeja[1]
[1]University of Potsdam, Germany

In this study, we present a detailed study of the IC444 reflection nebula. The presence of a binary star system at the center of the nebula is confirmed with high energy stars and Eclipse Binary (EB) stars. The temperature of the nebula ~10361±430 K. We focus on the study of the EB star at center of the nebula. The EB in the binary system has a period of ~3.1263974 days and it is identified red giant star. Also, the mass of star is ~0.47 $M_{\odot}$ and radius is ~ 0.99 $R_{\odot}$. The morphology of the nebula depends upon the EB stars.

Decoding Compact Hierarchical Triples using Eclipsing Binaries

Ayush Moharana[1]
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Compact hierarchical triples are triple star systems where the tertiary orbits the inner binary in an orbit less than 1000 days. These systems were thought to be rare but because of space-based photometric missions, we are discussing a lot of these systems. These systems are dynamic and their evolution is better studied simultaneously with their orbital evolution. If we have an eclipsing binary as the inner binary, we can obtain the stellar orbital and atmospheric parameters of all three stars in the system. I present my work which analyses photometric and spectroscopic data to understand the evolution of systems using precise stellar parameters.

Comprehensive Study of Ton 301, a Short-Period Binary with a Pulsating sdB Star

Shanti Priya Devarapalli[1], Vinay Kumar[1], Rukmini Jagirdar[1]
[1]Department of Astronomy, Osmania University, Hyderabad, India

Hot subdwarf B (sdB) stars are hot and compact stars with their Teff and log g ranging between 20 000–40 000 K and 5.2–6.2 respectively. They typically lie at the extreme horizontal branch's (EHB) blue end on the Hertzsprung-Russell (H-R) diagram. sdB stars are stars that have had a significant episode of mass loss during their evolutionary phase on the red giant branch. They are also known as post common-envelope systems, as indicated by their brief orbital durations of 1.2 hours to a few days. In this study, we present the first photometric and spectroscopic results of an sdB binary Ton 301, whose orbital period is relatively short i.e. 0.369822 days. The photometric light curve shows a noticeable phenomenon known as the reflection effect, which is distinguished by an amplitude of roughly 33% indicating the presence of a low-mass companion. Using the spectra collected from the 2-m Himalayan Chandra Telescope (HCT) and the sterne stellar atmosphere models, the Teff and log(g) values were found to be 28000 K and 5.75, respectively, to confirm object status as sdB. From the photometric solutions obtained using the Wilson-Devinney (WD) method, the absolute masses of both components are determined and the secondary component is found to be an M dwarf or brown dwarf companion. Along with the above a total of 31 frequencies were retrieved from the TESS data to study pulsations in the system. From the above results, we intend to discuss in detail the significance of such sources in understanding the fundamental stellar properties.

S Ant and epsilon CrA: New Data and Implications for Modelling

Ahmet Erdem[1], Volkan Bakış[2], Mark G. Blackford[3], Tom Love[4], Michael D. Rhodes[5], Adam Tang[6], Wu Zihao[7], Timothy S. Banks[8,9], Edwin Budding[10,11]

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[3]Variable Stars South, Congarinni Observatory, Congarinni, NSW, 2447, Australia

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New photometry and spectrometry of epsilon Corona Australis (eps CrA) and S Ant allow more intensive studies of these bright W UMa-type binaries, which will be briefly reviewed. This forms the backdrop for our attempt to gain a clearer insight into the general problem of the contact binary configuration.

The Binary System YY CrB Revisited Combining Light Curve Solution and Eclipse Timing

Somayeh Soomandar[1]

[1]Independent researcher, Kerman, Iran

This study presented new analysis of the W UMa binary system YY Coronea Borealis (YY CrB). The light curve was analyzed by Physics of Eclipsing BinariEs (PHOEBE) Python version together with the Markov chain Monte Carlo (MCMC) method. For a light curve solution, a hot spot and third light (l_3) are taken into account.

The minima times between 1991-2023 were collected and new eclipse times of minima were calculated during the TESS observation. Anti-correlated manner was observed between the O-C curve of primary and secondary minima that is a sign of existence of spots on the binary's components. A new linear ephemeris is reported for this target. By fitting a quadratic function to the O-C curve of minima, the orbital period rate $P=5.786\times10^{-8}$ day/year was calculated. Assuming mass conservation, a mass transfer rate $M=2.472\times10^{-8}$ $M_{\odot}year^{-1}$ calculated from the more massive star to less massive one. After removing the quadratic fit, the residuals revealed cyclic changes. Third body existence was therefore taken into consideration. Periodogram analysis was performed on the residuals of quadratic fit and period of 7351.018 days determined for the third body. By fitting Light Travel Time (LTT) function on the O-C curve, the mass of the third body derived as 0.498 $M_{\odot}$. Assuming the third body is a main-sequence star, this corresponds to the M1V spectral type with a brightness of 0.041 $L_{\odot}$ or 0.016 of the total luminosity which does not agree with the value l_3 determined in light curve solution. The O-C curve analysis and the quantity of mass indicate that the presence of a third body is unlikely. This binary is expected to evolve into a broken-contact phase and is a good case to support the thermal relaxation oscillation model.

SuperPhot, a Tool for Extracting High-Precision Photometry from Citizen Science Observation with DSLR Cameras

S. Javad Jafarzadeh[1]
[1]University of Texas at Dallas, United States

The photometric method for discovering exoplanets has prompted numerous space missions and ground-based surveys, resulting in the identification of thousands of exoplanets and candidates. However, the prohibitive cost of specialized detectors like CCDs has limited citizen scientist participation. To bridge this gap, we are developing accessible, high-precision photometry tools that utilize consumer-grade digital cameras and user-friendly software.

Our project involves:
- Creating an advanced software pipeline for extracting precise photometric data from observations made by citizen scientists using digital single-lens reflex (DSLR) cameras
- Implementing in the pipeline data acquisition from databases, calibration (including channel splitting and applying corrections like bias, dark, and flat fields), data reduction (covering astrometry, PSF fitting, aperture photometry, and magnitude fitting), and trend filtering (utilizing techniques like External Parameter Decorrelation, EPD, and Trend Filtering Algorithm or TFA).
- Collaborating with observational projects such as PANOPTES, which constructs cost-effective robotic telescopes equipped with DSLR cameras for exoplanet detection.

While our pipeline is still in development, we will present preliminary results from applying its current version to PANOPTES' test data.

Mass Transfer Effect on the Pulsations in Algol-type Systems

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The existence of pulsating stars in Algol-type eclipsing binary systems has been known for decades. Those pulsating variables generally exhibit oscillations different than single pulsators. In addition to tidal forces in Algol-type binaries, the mass transfer from the less massive cooler star to the massive hotter pulsating object could affect the pulsational behavior. In this study, we focus on the mass transfer amount on some Algol-type systems which include Delta Scuti-type oscillating stars. The main goal of the study is to find the effects of mass transfer amount on pulsations of Delta Scuti-type stars. For this purpose, we examined the TESS light curve of some Algol-type binaries with Delta Scuti pulsators and investigated those systems orbital period changes caused by mass transfer.

This study has been supported by the Scientific and Technological Research Council (TUBITAK) project through 120F330.

Zeta Chameleontis: A Newly Discovered Eclipsing Binary

Tom Love[1]
[1]Royal Astronomical Society of New Zealand, New Zealand

In 2021, Ijspeert et al. used TESS data to identify a large number of eclipsing binary systems including the very bright (visual magnitude around 5) Zet Cha. This had not previously been identified as an eclipsing system, probably as a consequence of a lack of observations due to its far Southern declination. This report summarises what was previously known about Zet Cha, and presents light curve analysis and spectroscopic data to characterise the system as a detached pair of early-type stars, exhibiting substantial stellar pulsation. The data suggest that there may be a third member of the system.

Eclipsing Symbiotic Stars Seen Through Different Eyes

Magdalena Otulakowska Hypka[1]
[1]Adam Mickiewicz University in Poznań, Poland

I will present examples of eclipsing symbiotic stars and our observations of such systems. By using a number of different observational methods together, we are able to model these stars and derive precise system parameters. Such research is important for improving stellar models, as well as for our understanding of binary stellar systems in general.

Multiband Photometry and Light Curve Analysis of a Southern Hemisphere Binary System: EL Tuc

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The first light curve solution of the EL Tuc contact binary system is presented. We made use of our ground-based opportunity at a southern hemisphere observatory for multiband photometry observations. We extracted times of minima from our observations and calculated a new ephemeris. We performed light curve analysis along with the Markov chain Monte Carlo (MCMC) method. In addition, we estimated the absolute parameters of the system using the Gaia parallax method.

Importance of Binaries Stars in Astrophysics

Danielle Briot[1]
[1]Observatoire de Paris, France

Many stars are binary stars or multiple systems and the rate of these systems increases according to the mass and temperature of the stars. Scenarios of star formation would explain this result. Some fundamental physical parameters of stars, namely the stellar mass and the stellar diameter, could only be determined using binary stars. An original method to discover circumbinary planets is given by the timing of eclipses. Also, the first detected black hole Cyg X1 is a component of a couple of stars, one of them being at the end of evolution. Additionally, acceleration of the expanding Universe was detected from cosmic candles supernovae Ia, the progenitors being binary stars. Gravitational waves detected for the first time in 2016 are coming from a colliding couple of stellar mass black holes, or neutron stars.

Evolutionary Modeling of Some δ Scuti Pulsators in Semi-Detached Binaries

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The Eclipsing binary stars are very important objects in better understanding stellar astrophysics and galaxy structure. Binary star systems with pulsating components play a critical role in enhancing our understanding of stellar internal structures, leading to more precise insights into stellar configurations. Especially, when binary stars with pulsating components possess a semi-detached structure, the mass transfers and interactions between the components are essential for comparison of observational and theoretical models due to their impact on both stellar evolution and pulsation structure. In this context, evolution models were produced using detailed photometric investigations of some semi-detached binary systems with pulsating components selected within the scope of this study. In this way, interstellar interactions were carefully examined, taking into account mass transfer and losses, and the ages of the systems were determined.

This study has been supported by the Scientific and Technological Research Council (TUBITAK) project through 120F330.

Light Curve Study of the Low Mass Contact Binary V0610 Vir

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Photometric data were used to perform the first light curve analysis of the V0610 Vir binary system. We extracted the minima from our observations and compiled the literature, which was few in number. Therefore, we performed computations using the reference ephemeris and presented a new ephemeris and O-C diagram with a linear fit. Light curve analysis was performed using the PHOEBE Python code and the Markov chain Monte Carlo (MCMC) approach. The assumption of a cold spot was required due to the asymmetry in the light curve's maxima. The analysis shows that V0610 Vir is a contact binary system with a fillout factor of 0.085, a mass ratio of 0.998, and an inclination of 70.65°. The absolute parameters of the system were estimated based on the Gaia DR3 parallax method. The results show that the system is a Low-Mass Contact Binary (LMCB) with a total mass lower than 0.8($M_{\odot}$). The location of the stars was shown in the $M-L$ and $M-R$ diagrams.

First Light Curve Analysis of the V1023 Her and V1397 Her W UMa-type Systems

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The study of contact binary systems using space-based data that has very suitable observations can be valuable. Therefore, two W UMa-type binary systems, V1023 Her and V1397 Her, were analyzed for the first time. Several sectors of TESS data were used to calculate the new ephemeris, and the light curve analysis of these two systems was presented using the MCMC method.