The formation and long-term evolution of circumbinary planetary systems across the H-R diagram

Report of Contributions

https://indico.ict.inaf.it/e/circumbinary-planetary-systems

Contribution ID: **1** Type: **not specified**

Observations of circumbinary discs and their alignment across a range of stellar populations

Tuesday 14 January 2025 09:55 (35 minutes)

Circumbinary planets form from material in protoplanetary disks. Therefore it is reasonable to expect that planets would inherit their orbits from the distribution of this material, at least in a broad and initial sense. In this talk, I will review observations of circumbinary material across stellar ages: from the earliest protostellar and class 0/I systems, through the "classic" class II protoplanetary disks orbiting orbiting pre-main sequence stars, to circumbinary debris disks orbiting main sequence stars. I will cover the diverse means by which these circumbinary systems are observed with a special focus on how the mutual inclination between the stellar and disk planes is calculated and the ambiguities that may result.

Presenter: CZEKALA, Ian

Session Classification: CB disc properties and planet formation

Contribution ID: **2** Type: **not specified**

Observations of multiple body systems with ALMA

Tuesday 14 January 2025 10:30 (35 minutes)

The physical properties and dynamics of the youngest multiple protostellar systems and their disks have remained largely unconstrained due to their embedded nature. In this talk, I will discuss recent high-resolution ALMA observations, which are beginning to resolve the gas and dust emission within individual and circumbinary disk structures during the earliest stages of formation. These observations provide a first view into the gas kinematics, gas/dust temperatures, and amount of material in circumstellar and circumbinary disks in young multiple systems. Furthermore, I will highlight efforts to integrate multi-epoch observations from ALMA and the VLA, which have allowed for independent constraints of protostellar masses and orbital parameters in some close separation protostellar binary systems.

Presenter: MAUREIRA, Maria Jose

Session Classification: CB disc properties and planet formation

Contribution ID: **3** Type: **not specified**

Phased accretion and a dynamically-truncated eccentric circumbinary disc cavity in a pre-main-sequence binary system

Tuesday 14 January 2025 11:35 (35 minutes)

Pre-main-sequence binary systems provide a unique laboratory for studying dynamical truncation in discs. We studied the inner region of a nearby Herbig Ae/Be binary system using the VLTI/GRAVITY and VLTI/PIONIER instrument. Spectrally-dispersed interferometry with GRAVITY allowed us to determine the origin of the Br γ line emission and to study how the accretion rates on the primary and secondary vary over the orbit. We constrained the orbit and dynamical masses of the stars, and resolved dust arranged in a circumbinary disc. The measured inner disc radius is considerably larger than the theoretical dust sublimation radius, suggesting that the disc is dynamical truncated by the binary. One side of the circumbinary disc appears consistently brighter, indicating that the disc cavity is eccentric, which matches the prediction from smooth-particle hydrodynamic simulations of eccentric binaries. Finally, we found that the variable Br γ line emission is associated with accretion onto the primary and secondary. We derived the individual accretion rates and found that the primary accretes at roughly constant rate, while the accretion rate on the secondary is strongly phase-dependent and peaks around periastron passage.

Presenter: KRAUS, Stefan

Session Classification: CB disc properties and planet formation

Contribution ID: **4** Type: **not specified**

Hints of planet formation signatures in a large-cavity disk studied in the AGE-PRO ALMA Large Program

Tuesday 14 January 2025 12:10 (20 minutes)

Detecting signatures of planet formation in protoplanetary disks is essential for understanding how and where planets form. In this talk, I will present dust and gas observations of the disk around 2MASS J16120668-301027, studied as part of the ALMA Large Program 'AGE-PRO: ALMA Survey of Gas Evolution in Protoplanetary Disks,' where several indicators of planet formation were recently identified in dust continuum emission and four molecular lines.

Presenter: SIERRA, Anibal

Session Classification: CB disc properties and planet formation

Contribution ID: **5** Type: **not specified**

Stellar binary formation and the disc properties of binary systems

Tuesday 14 January 2025 14:00 (35 minutes)

I will discuss the formation mechanisms and resulting properties of stellar binary systems that are obtained from radiation hydrodynamical simulations of star cluster formation. I will also discuss the properties of the protoplanetary discs that are formed with these systems, concentrating on the frequencies and properties of circumbinary discs.

Presenter: BATE, Matthew

Session Classification: CB disc properties and planet formation

Contribution ID: **6** Type: **not specified**

Evolution of stellar binaries surrounded by circumbinary disks

Tuesday 14 January 2025 14:35 (35 minutes)

I will discuss the hydrodynamics of circumbinary disks and how it impacts the binary evolution of the formation of planets.

Presenter: LAI, Dong

Session Classification: CB disc properties and planet formation

Contribution ID: **7** Type: **not specified**

Kinematic signatures of circumbinary disks

Tuesday 14 January 2025 15:10 (35 minutes)

Systems where two gravitationally bound masses (the primary mass and its binary companion) interact with the surrounding gas and dust are extremely common in the Universe and encompassing a wide variety of different astrophysical systems, from stars and planets to black holes. Extensive theoretical and numerical work from the late 1970s revealed that the material in the surroundings of binaries forms a disc structure around the binary, called "circumbinary disc". The perturbative effects from the companion produce a variety of features in such discs, each carrying distinct kinematic signatures. The great advancements during the past decade in our observational capabilities allowed us for the first time to observe such features in protostellar discs, providing us with spatially resolved kinematic maps of protostellar discs, triggering extensive theoretical work aimed at interpreting the data. In this talk, after a general overview of binary-disc interaction theory, I will present the ongoing efforts to model the kinematics of protostellar discs when companions (massive planets or stellar binaries) are present. I will discuss the current progress and highlight some open issues that still require to be addressed. In particular, I will focus on the growth of disc eccentricity and inclination as characteristic features of circumbinary discs, and how their measurement could be in principle used for detecting unseen binaries. I will discuss the kinematic appearance of disc orbital eccentricity and inclination through the eyes of ALMA, and present an analytical model for their characterisation benchmarked against numerical hydro+MCRT numerical simulations. In the light of the results presented, I will finally stress the importance of moving beyond circular coplanar disc models for the interpretation of protostellar discs kinematics in general.

Presenter: RAGUSA, Enrico

Session Classification: CB disc properties and planet formation

Contribution ID: **8** Type: **not specified**

Polar discs and circumbinary formation in highly misaligned discs

Tuesday 14 January 2025 16:15 (35 minutes)

Most stars born in dense stellar clusters are part of binary star systems. Circumbinary discs of gas and dust commonly surround binary star systems. Misalignments between the circumbinary disc and the binary orbital plane are widely observed. A misaligned circumbinary disc undergoes nodal precession. For a low initial inclination, the precession is around the binary angular momentum vector, while for a sufficiently high initial inclination, the precession is around the eccentricity vector. Dissipation causes the disc to evolve to align coplanar to the binary orbital plane or perpendicular (i.e., polar) to the binary orbital plane. I present 3-dimensional hydrodynamical simulations and linear theory on the evolution of highly misaligned circumbinary discs. I show that misaligned circumbinary discs are favorable environments for forming misaligned and polar circumbinary planets. The evolution of protoplanetary discs around binary star systems bears important implications for planet formation and the diversity of exoplanets.

Presenter: SMALLWOOD, Jeremy

Session Classification: CB disc properties and planet formation

Contribution ID: **9** Type: **not specified**

Hydrosimulations of circumbinary discs hosting circumbinary planets

Tuesday 14 January 2025 16:50 (35 minutes)

Formation and evolution of circumbinary planets are strongly related to the physics of their native circumbinary discs. Having a comprehensive picture of circumbinary discs is therefore a prerequisite for understanding these processes. Given the sensitivity of the circumbinary disc structure to the detailed disc physics, this requires realistic circumbinary disc modelling. In this talk, we will present recent models of circumbinary discs that incorporate both 3-dimensional effects and a realistic treatment of disc thermodynamics. We will present how these sophisticated models compare to traditional two-dimensional models, and discuss how they impact the in-situ and migration scenarios for the formation of circumbinary planets.

Presenter: PIERENS, Arnaud

Session Classification: CB disc properties and planet formation

Contribution ID: **10** Type: **not specified**

Planet-disk interaction in circumbinary disks

Wednesday 15 January 2025 09:15 (35 minutes)

"As of today we have about a dozen confirm planets that orbit both binary stars. These planets must have formed and evolved in the protoplanetary, circumbinary disc. To gain a full understanding of the observed planet we need to trace them backwards in time and investigate the planet migration within the disc and how the binary potential can dictate the final orbit of the planets and how the planets can reshape the structure of the disc beyond their location.
This work has started more than a decade ago with the discovery of Kepler-16b. The complex interaction between viscous flow, and wave propagation and gravitational interaction of the binary, planet and disc leaves us till today with some mysteries and a highly sensitive test case to see if we understand planet formation yet.
In this talk, I will discuss the past decade of hydrodynamic simulations and the progress we have made to explain the population of known circumbinary planets through numeric models.

Presenter: PENZLIN, Anna

Session Classification: CB disc properties and planet formation

Contribution ID: **11** Type: **not specified**

The formation of circumbinary terrestrial planets via core accretion

Wednesday 15 January 2025 09:50 (20 minutes)

Using a combination of N-body simulations and hydrodynamic models, we explore how terrestrial planets form around binary stars through planetesimal accretion. We consider planet formation around both circular and eccentric binaries and in planetesimal disks that are coplanar, polar, or misaligned to the binary orbital plane. We find that terrestrial planet formation via core accretion around an eccentric binary is more likely in the polar alignment than the coplanar alignment. Solid bodies in misaligned disks undergo differential nodal precession that results in high collision bodies and fragmentation. In this case, planet formation is mostly inhibited and instead, interstellar asteroids are generated.

Presenter: CHILDS, Anna

Session Classification: CB disc properties and planet formation

Contribution ID: **12** Type: **not specified**

An overview of circumbinary population with Kepler & TESS

Wednesday 15 January 2025 10:10 (35 minutes)

It has been almost 15 years since the breakthrough discovery of Kepler-16, which was the first unambiguous detection of a planet orbiting both stars in a binary system with main sequence stars. Thanks largely to the Kepler and TESS missions, around 20 such circumbinary planets have already been detected and some trends seem to have emerged. Unraveling the characteristics of these circumbinary planets is of fundamental value in astronomy as this new class of planets allows us to probe questions regarding the formation, migration, evolution and habitability of planetary systems in a larger context. In this contribution I will review how these circumbinary planets are detected and characterized, highlight a few recent discoveries, and discuss some emerging observational trends in this small but growing sample.

Presenter: OROSZ, Jerome

Session Classification: MS systems

Contribution ID: **13** Type: **not specified**

Finding Circumbinary Planets: A Transit Detection Framework for TESS Eclipsing Binaries

Wednesday 15 January 2025 11:15 (20 minutes)

The detection of circumbinary planets (CBPs) represents an exciting breakthrough in exoplanetary science. However, the number of known CBPs remains small; out of the several thousand known transiting exoplanets, only 14 are CBPs. This small sample size presents a challenge for studying the formation, evolution, and bulk properties of CBPs. In this contribution, I will present a framework for detecting transiting CBP candidates from TESS light curves of eclipsing binaries. I will outline how the data are processed, as well as the procedure for detecting and vetting candidate transit events. By applying this framework to the known transiting CBPs, as well as performing injection-recovery tests, I will present my findings on the detection efficiency of the framework. Finally, I will highlight any potential candidates that have been identified so far and consider future applications of this work.

Presenter: DAVIES, Benjamin

Session Classification: MS systems

Contribution ID: **14** Type: **not specified**

Don’t FORCES It - Toward an occurrence rate of transiting TESS CBPs

Wednesday 15 January 2025 11:35 (20 minutes)

NASA’s Transiting Exoplanet Survey Satellite (TESS) has revolutionized our understanding of nearby low-mass stars, providing a wealth of data for exploring planetary systems in unprecedented detail. We can leverage this excellent dataset to study TESS’s sample of low-mass M+M binaries, which offers interesting cross-sectional science merit from both stellar and planetary perspectives. I am investigating the occurrence rate of circumbinary planets (CBPs) in low-mass M+M binaries, a population which has not yet been explored in previous studies. In this talk, I will briefly motivate the study of transiting CBPs, with special focus on new science with M+M binaries. I will then discuss my work to characterize eclipsing binaries and outline my transit search methodology, which I have termed “FORCES”. I will present current progress towards finding the occurrence rate of transiting CBPs with TESS.

Presenter: ODDO, Dominic

Session Classification: MS systems

Contribution ID: **15** Type: **not specified**

Searching for circumbinary planets using orbital dynamics

Wednesday 15 January 2025 11:55 (35 minutes)

Planets orbiting single stars transit almost strictly periodically. Yes, there can be some small transit timing variations (TTVs), but these are typically on the order of seconds or minutes. Fundamentally, we find planets around single stars assuming periodic transits, and then characterise any TTVs after the fact. This is not possible for circumbinary planets because geometry and 3-body dynamics create TTVs on the order of hours, days or even weeks. The TTVs are larger than the transit durations, which to further complicate things, also vary. I will demonstrate methodology and results from the STANLEY planet search, which directly incorporates dynamics into the search algorithm.

Presenter: MARTIN, David

Session Classification: MS systems

Contribution ID: **16** Type: **not specified**

Low mass and long period circumbinary exoplanets

Wednesday 15 January 2025 14:00 (35 minutes)

Since 2018 the BEBOP radial velocity survey for circumbinary exoplanet has been monitoring 100 main sequence binaries in both hemispheres. In this talk I will how we have managed to detect circumbinary planets in single as well as double-lined binaries. I will also show preliminary results about a number of other credible candidates. We find that we do not see the same population of planet than was detected via transit. We postulate this is because many circumbinary planets might be low mass, but high radius planets.

Presenter: TRIAUD, Amaury

Session Classification: MS systems

Contribution ID: **17** Type: **not specified**

Orbital stability of circumbinary system

Wednesday 15 January 2025 14:35 (35 minutes)

In this talk we revisit the problem of the stability of circumbinary planetary orbits and how to identify stable and unstable motion in such cases. In the first part of the talk, we discuss some past results and how the problem has been dealt with so far. We present some stability criteria along with their advantages and disadvantages. In the second part of the talk, we present the latest developments in the problem of circumbinary stability. In that context, we carry out more than 3x10^8 numerical simulations of planets between the size of Mercury and the lower fusion boundary (13 Jupiter masses) which revolve around the center of mass of a stellar binary over long timescales. For the first time, three dimensional and eccentric planetary orbits are considered. The results of the numerical integrations provide us with two critical borders: an outer border beyond which all planetary orbits are stable and an inner border closer to the binary below which all planetary orbits are unstable. In between the two borders, a mixture of stable and unstable planetary orbits is observed. We provide empirical expressions in the form of multidimensional, parameterized fits for the two borders that separate the three dynamical domains. Moreover, we train a machine learning model on our data set in order to have an additional tool for predicting stable and unstable motion. Both the empirical fits and the machine learning model are tested against randomly generated circumbinary systems. The empirical formulae are also applied to the Kepler and TESS circumbinary systems, confirming the stability of the planets in these systems. Finally, the empirical fits are compared against previously derived stability criteria.

Presenter: GEORGAKARAKOS, Nikolaos

Session Classification: MS systems

Contribution ID: **18** Type: **not specified**

Formation of free-floating planets from CB systems

Thursday 16 January 2025 10:00 (35 minutes)

In recent years, free floating planets, i.e. those planets not found to be in a planetary system and with no observable companions, have begun to be found in microlensing and direct imaging surveys. Observations have shown that they have a wide variety of masses, ranging from terrestrial-like to giant planets. Microlensing surveys predict that there could be on order tens of free floating planets per star in the Milky Way. How these planets form and arrive on their observed trajectories remains a very open and intriguing question. Whilst there are many mechanisms for forming free floating planets, e.g. ejections from planet-planet interactions or gravitational collapse of gas within molecular clouds, very few models have predicted the properties of free floating planets on a global scale. In this presentation I will present the outcomes of state-of-the-art circumbinary planet formation models, that naturally produce a large abundance free floating planets per system. I will show the resulting mass and velocity distributions arising from the models, which will then be extended to include stellar populations of both single and binary stars, taking into binary fractions, and separations. The population distributions show clear observable features that can be investigated by future missions such as Roman, where evidence of these features will directly point to the specific formation pathways of specific planets, as well as informing on the processes of the planet forming environment in which they originated.

Presenter: COLEMAN, Gavin

Session Classification: Binary and triple systems evolution

Contribution ID: **19** Type: **not specified**

Long-term evolution of circumbinary exoplanets

Thursday 16 January 2025 10:35 (35 minutes)

Notwithstanding the tremendous growth of the exoplanetary field in the last decade, circumbinary planets (CBPs) remain a small fraction of the total discoveries to date: around fifty CBPs have been identified out of nearly six thousand exoplanets, primarily detected through eclipse timing variations and transits. Almost a third of these orbit post-main-sequence stars, which suggests their ability to survive the demise of their binary hosts. Given the ubiquity of binary and multiple star systems in the Milky Way, CBPs should be widespread. However, current observational biases may be hindering their detection. Considering the limited sample of discovered CBPs, their statistical characterisation still requires theoretical investigation.
In this talk, I will discuss the long-term evolution of CBPs from a population perspective. We simulated the temporal evolution of giant CBPs, tracing their development from the main sequence to white dwarf stages, up to the age of the Universe, in order to provide theoretical constraints on their parameter space.Between 23% and 32% of all CBPs survive to eventually orbit a double-white-dwarf host, which we have labelled “Magrathea” planets. These gas giants can survive the death of their hosts if they orbit at a sufficient distance to avoid engulfment and instabilities. Magratheas are a natural outcome of CBP evolution and are likely to be relatively common in the whole Milky Way, where they could be detected via gravitational waves with the future ESA-LISA mission.

Presenter: COLUMBA, Gabriele

Session Classification: Binary and triple systems evolution

Contribution ID: **20** Type: **not specified**

Stellar Evolution in Planetary Systems: How White Dwarf Formation Kicks Can Reshape Orbital Architectures

Thursday 16 January 2025 11:40 (35 minutes)

Observations of evolved stellar binaries over recent years have revealed that stars undergo a mild kick during their evolution into White Dwarfs, most likely caused by a slight asymmetry in their mass loss via stellar winds towards the end of the AGB phase. This kick has a significant impact on the dynamical evolution of stellar binaries and triples, which can cause such systems to separate, but can also lead to stellar collisions. In recent works, I have shown that these kicks can also have a tremendous impact at shaping the evolution of planetary systems and their observations, for example by aiding Hot Jupiter formation in evolving binary star systems, and by obscuring the true dynamical evolution histories of planets around single stars that originated in, later kick-separated, binaries. In this talk, I will present various dynamical processes enabled by White Dwarf formation kicks and stellar evolution, including their implications for circumbinary planets, circumstellar planets in wide binaries, and planets around single stars.

Presenter: STEPHAN, Alexander

Session Classification: Binary and triple systems evolution

Contribution ID: **21** Type: **not specified**

The Dynamical Evolution of Planets Orbiting Interacting Binaries

Thursday 16 January 2025 12:15 (20 minutes)

About 15% of solar-type stars are in such close binaries that interaction is bound to occur as the stars evolve and swell. Around 5600 planets have been detected in solar types of stars. However, only about twenty circumbinary planets have been identified. Understanding the intricate dynamics within such complex systems is crucial for unraveling the processes of planet formation and binary evolution and constraining the detection of planets in binary systems. The tightest orbit binaries would harbor the most dynamically stable and enduring circumbinary planetary systems; however, they are also prone to experience mass transfer, common envelope evolution, or stellar mergers. Subdwarfs are one of the most common products resulting from binary evolution. They are both long-lived and easy to recognize. Understanding the impact of subdwarf formation on the surrounding planetary system constitutes one of the most promising avenues for revealing how binary evolution, in general, affects planetary systems. We have developed an integration framework to unravel the complex dynamics of planets around evolved and interacting binaries. This framework seamlessly combines binary evolution data from the MESA stellar evolution code with a detailed N-body simulation within the REBOUND environment. To ensure numerical robustness, we have devised a binary star model including a circumbinary planet and implemented a recalibration method to address errors stemming from updates in binary properties during dynamical computations. Our findings indicate that the closest stable orbital separation for circumbinary planets is approximately 2.5 times the binary separation following mass transfer. In this presentation, I will introduce our new model and our latest results of the evolution of planets orbiting binaries that evolve into white dwarfs or subdwarf systems.

Presenter: TORRES, Santiago

Session Classification: Binary and triple systems evolution

Contribution ID: **22** Type: **not specified**

Origin of eclipsing time variations in post-common-envelope binaries

Thursday 16 January 2025 14:15 (35 minutes)

Eclipsing time variations in post-common-envelope binaries can be interpreted to be due to the presence of a third body (light-travel time effect) or to be a result of stellar magnetism, leading to the presence of a time-dependent quadrupole moment in the star causing time-dependent variations in the orbit period. In this talk, I will present 3D magneto-hydrodynamical simulations of stellar dynamos and their effect on the stellar interior, giving rise to a time-dependent quadrupole moment. I will further then present numerical simulations of post-common-envelope binaries with such a time-dependent quadrupole moment to show how these can produce the observed O-C diagrams.

Presenter: SCHLEICHER, Dominik

Session Classification: Post MS systems

Contribution ID: **23** Type: **not specified**

Observations of CBP exoplanets beyond the Main Sequence

Thursday 16 January 2025 14:50 (20 minutes)

Presenter: KLAUS, Beuermann

Session Classification: Post MS systems

Contribution ID: **24** Type: **not specified**

A White Dwarf triple system in the Globular Cluster NGC6397

Thursday 16 January 2025 15:10 (20 minutes)

The high stellar density in globular clusters produces a variety of intriguing objects resulting from binary interactions, such as blue stragglers, cataclysmic variables, and millisecond pulsars. Binaries play a critical role in the dynamical state of the cluster, as the orbital energy stored in these systems can prevent or delay core collapse. Comparing observed and predicted binary properties provides valuable insights into cluster evolution. Using MUSE spectroscopy, we have investigated the properties of binaries in globular clusters. Recently, we extended this work to explore the presence of triple systems, which are even more sensitive indicators of cluster dynamics. In this talk, we will present the discovery of a white dwarf triple system.

Presenter: DREIZLER, Stefan

Session Classification: Post MS systems

Contribution ID: **25** Type: **not specified**

Observations of post-AGB discs

Thursday 16 January 2025 16:00 (35 minutes)

Both planets and discs are detected in binary systems beyond the main sequence. In particular, many post-asymptotic giant branch (post-AGB) binary systems are found to host circumbinary discs. These discs, created from the material of the evolved star during some yet poorly understood binary interaction phase, show many similarities with protoplanetary discs around pre-main sequence stars. These include dust mass, Keplerian rotation, infrared excesses, dust mineralogy, and the disc physics near the dust sublimation rim. These similarities raise the question whether a second episode of planet formation processes are taking place in these discs around post-AGB binaries. In this talk I will give an overview of the observational campaigns that have been ongoing over the last few years to uncover the structure and evolution of the circumstellar environment of the binary systems far beyond the main sequence. I will show observational results covering different wavelengths, from the optical to the submillimetre, and discuss how these multi-wavelength, and thus multi-scale, datasets can help our understanding of circumbinary planetary system formation and evolution.

Presenter: CORPORAAL, Akke

Session Classification: Post MS systems

Contribution ID: **26** Type: **not specified**

Formation of second-generation exoplanets around double white dwarfs

Friday 17 January 2025 09:30 (20 minutes)

The evolution of binaries that become double white dwarfs (DWDs) can cause the ejection of high amounts of dust and gas. This material can give rise to circumbinary discs and become the cradle of new planets, yet no studies to date have focused on the formation of circumbinary planets around DWDs. DWDs will be the main sources of gravitational waves detectable by the Laser Interferometer Space Antenna (LISA) mission, opening the possibility to detect circumbinary planets around short-period DWDs via the modulation of their GW signal. My contribution will present multiple planet formation tracks showing how the planetary formation processes typical of pre-main sequence discs are affected by the disc environments surrounding DWDs, accounting for accretion rate onto the central binary and the disc photoevaporation rate caused by stellar irradiation. The simulations show that planetary formation should be common in circumbinary discs around DWDs, but the formation of gas giants in particular can be hindered by the temperatures of the disc and the rapid disc depletion. In particular, the metallicity and accretion rate of the disc, and the timing of planet formation represent the key parameters discriminating between the different nature of the final planets.

Presenter: LEDDA, Sebastiano

Session Classification: Post MS systems

Contribution ID: **27** Type: **not specified**

Orbital stability of circumbinary exoplanets orbiting double white dwarfs.

Friday 17 January 2025 09:50 (20 minutes)

The formation and stability of planetary systems around compact binaries, such as double white dwarfs (DWDs), represent a frontier in planetary science, with implications for understanding planet formation in extreme environments. Recent theoretical studies suggest that second-generation planets can form in circumbinary discs around DWDs, potentially evolving into systems hosting sub-Neptunian to giant planets. However, the long-term orbital stability of these systems remains poorly explored. In this study, we present results from N-body simulations investigating the dynamical stability of circumbinary planetary systems around DWDs over timescales of a few million years. Employing a hybrid symplectic integrator tailored for circumbinary systems, we simulate two-, three-, and four-planet configurations, analyzing their evolution through metrics such as orbital spacing, center-of-mass variation, and Normalized Angular Momentum Deficit (NAMD). Our findings demonstrate that planetary systems around DWDs can remain stable over the studied timescales. Two-planet systems exhibit no catastrophic events, while higher multiplicity systems often experience phases of dynamical instability, leading to planet loss. Ultimately, most systems stabilize with two surviving planets, increasing their prevalence by 23% relative to their initial abundance. Conversely, systems with higher initial multiplicities face significant reductions, with four-planet configurations decreasing by 42%. Notably, 4% of multi-planet systems are disrupted entirely due to planetary collisions with the central binary. Our work advances the understanding of planetary system dynamics in post-main-sequence environments and offers insights into the formation and survival of planets in circumbinary systems.

Presenter: NIGIONI, Arianna

Session Classification: Post MS systems

Contribution ID: **28** Type: **not specified**

Circumbinary planets with Gaia

Friday 17 January 2025 10:10 (35 minutes)

Gaia data release 4 is around the corner, and it will include the release of all the individual epoch astrometry for the first 5 years of the mission. Predicted to include 10s of thousands of exoplanets, it is less clear exactly what impact the Gaia data will have on circumbinary planet science. I will present up-to-date predictions of the expected yield of circumbinary planets from Gaia and discuss its application to known systems for confirmation of planet status and measurements of mutual inclinations between binary and planetary orbits.

Presenter: BAYCROFT, Thomas

Session Classification: Future perspectives

Contribution ID: **29** Type: **not specified**

Circumbinary planets with the Nancy Grace Roman Space Telescope

Friday 17 January 2025 11:15 (35 minutes)

The Nancy Grace Roman Space Telescope (Roman) is a NASA mission that is scheduled to launch in October 2026. Roman will have similar sensitivity and resolution to Hubble but will be able to survey the sky around 1400x faster. Around 25% of the first 5 years of the mission will be devoted to a near-infrared time domain survey of the Galactic bulge that is expected to find around 1,500 cool exoplanets using microlensing, and up to 200,000 hot exoplanets with the transit method. I will overview the huge opportunities that Roman will provide for exoplanet demographics, including the identification and study of circumbinary planetary systems.

Presenter: KERINS, Eamonn

Session Classification: Future perspectives

Contribution ID: **30** Type: **not specified**

Circumbinary planets with PLATO

Friday 17 January 2025 11:50 (35 minutes)

An overview over science with circumbinary planets in the context of the PLATO space mission will be given.

Presenter: DEEG, Hans

Session Classification: Future perspectives

Contribution ID: **31** Type: **not specified**

Circumbinary planets with the LISA space mission

Friday 17 January 2025 14:00 (25 minutes)

The discovery and study of exoplanets in their diversity is arguably one of the most exciting development in astronomy over the past 25 years, rivalled by the detection of gravitational waves.
In this talk I will merge these two fields presenting an original observational method which employs gravitational waves to detect exoplanets.
In particular I will show how the Laser Interferometer Space Antenna (LISA) mission will be able to observe Jupiter-like exoplanets orbiting compact white dwarfs binaries emitting gravitational waves at mHz frequencies.
This technique will allow us to both overcome the selection bias of current electromagnetic detection techniques, whose observations are limited to the Solar neighbourhood, and to search for post-main sequence exoplanets everywhere within the Milky Way and the Magellanic Clouds.
Detections by LISA will deepen our knowledge on the life of Magrathea exoplanets subsequent to the most extreme evolution phases of their hosts, clarifying whether new phases of planetary formation take place later in the life of the stars.

Presenter: DANIELSKI, Camilla (Istituto Nazionale di Astrofisica (INAF))

Session Classification: Future perspectives