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Annual Report March 2023

Commission G1 covers a very broad range of topics including both observations and theoretical modelling of binary and multiple systems. Probably the most important contributions in the last year have again come from surveys and the production of catalogues. In particular the Gaia DR3 Catalogue, released in June 2022, contains information on duplicity of the observed stars for the first time. Orbits have been determined for more than 433,000 multiple stellar systems though perhaps half of these are not to be trusted. The Catalogue contains data on 2,184,477 eclipsing binary stars. Several dozen stars in Gaia DR3 have substellar and planetary companions. Other surveys include, in the framework of the Araucaria project, high-precision orbital parallaxes and masses of binary stars by VLTI/GRAVITY observations of ten double-lined spectroscopic binaries (Gallenne et al., arXiv:2302.12960) and ARMADA II for further detections of inner companions to intermediate-mass binary stars with microarcsecond astrometry at CHARA and VLTI (Gardner et al., 2022, AJ, 164, 184).

As we approach the deadline for the annual report, ADS lists 7134 papers from January, 2021 to December 2022 with the phrase binary star in the abstract or key words. Many of these are written by our Chinese colleagues. And it is great to see interest in our field growing internationally. The most cited paper logged 1251 citations and, as did the next three, dealt with LIGO/Virgo results. Numbers 5, 9, 15, 16 and 18 concerned results from Gaia data releases. Numbers 7 and 14 asked about the properties of PSR J0740+6620 and the implications of its very large mass for the equation of state of dense nuclear matter. Numbers 8 and 12 are reports on the status of space missions, eRosita and DECIGO. Number 11 explored possible origins for binary black holes and there are a couple more LIGO/Virgo papers in there.

An interesting study of nine compact triply eclipsing triples by Rappaport et al. (2023, MNRAS, 521, 558) reports on the independent discovery and analysis of nine new systems found by the TESS satellite. Each of these exhibits distinct third-body eclipses for which the third star occults the inner eclipsing binary or vice versa. A photodynamical analysis of the TESS photometry was used together with archival photometric data, TESS eclipse timing variations, spectra and, in some cases, newly acquired radial velocity observations, to solve for the parameters of all three stars, as well as most of the orbital elements. In a similar vein V994 Herculis has been found to be a unique triply eclipsing sextuple star system by Zasche et al. (2023, MNRAS, 520, 3127). They discovered a third set of eclipses on top of the previously only known double eclipses. This makes V994 Her only the second fully characterised (2+2)+2 sextuple system, in which all three binaries eclipse.

Planetary nebulae hosting accreting white dwarfs give a possible solution for the mysterious cut-off of Planetary Nebula Luminosity Function. The frequency of binary systems among central stars of planetary nebulae has been actively studied for several decades.

Souropanis et al. (2023, MNRAS, 521, 1808) argue that accreting white dwarfs in interacting binaries might play a role in understanding the invariant cut-off to the Planetary Nebula Luminosity Function, an important method used to determine extragalactic distances on the cosmological distance ladder.

Various meetings related to the Commission’s work have taken place and it is good to see a vibrant community emerging from the isolation of lockdowns. Among these “Stellar evolution along the HR diagram with Gaia”, in Naples 20th to 23rd September 2022 included invited talks on “Multiple stellar systems in Gaia DR3” (Barstow) and “Understanding binary stars with Gaia” (Izzard) along with a number of other talks related to binary systems. Others included, “The fundamental role of stellar multiplicity in stellar dynamics and evolution”, 31st October to 25th November 2022 and “The Impact of Binaries on Stellar Evolution”, from 14th to 18th November 2022, both in Garching bei München, Germany.

Finally we list some other interesting papers related to the Commissions work.

Discoveries of a stripped binary component: the famous HR 6819 system without the previously claimed black hole component, Frost et al. 2022, A&A 659, L3.

Apsidal motion in massive eccentric binaries in NGC 6231 Rosu et al. 2022, A&A 660, A120 in which the authors provide essential information to probe the internal structure of the stars that compose the system.

Apsidal motion in massive eccentric binaries: The case of CPD $-41^{\circ}7742$, and HD 152218 revisited Rosu et al. 2022, A&A 664, A98.

”Stellar and substellar companions from Gaia EDR3. Proper-motion anomaly and resolved common proper-motion pairs”, Kervella et al. 2022 A&A, 657, 7.

And of a theoretical nature.

Stripped-envelope stars in different metallicity environments I. Evolutionary phases, classification, and populations, Aguilera-Dena et al. 2022, A&A 661, A60.

Rejuvenated accretors have less bound envelopes: Impact of Roche lobe overflow on subsequent common envelope events, Renzo et al. 2023, ApJ, 942, L32.

Mergers prompted by dynamics in compact, multiple-star systems: a stellar-reduction case for the massive triple TIC 470710327, Vigna-Gomez et al. 2022, MNRAS 515, L50.

A unified model for the evolution of cataclysmic variables, Sarkar & Tout 2022, MNRAS, 513, 4169.