

PROGRAM

MONDAY 3

8h00–9h20 **Registration**

9h20–9h40 **Welcome & Opening remarks** Anne-Sophie Libert (chair of the SOC)

9h40–10h20 A. Morbidelli, *Interdisciplinarity: an effective approach to comprehending the formation of planetary systems*

10h20–11h00 **Coffee break**

11h00–11h40 D. Scheeres, *Binary Asteroids: A Pathway to Understanding the Morphological Evolution of Rubble Pile Asteroids*

11h40–12h20 D. Fabrycky, *Resonant Chain Dynamics: Interpretation of Observations*

12h20–12h25 A. Füzfa, *The UNamur observatory*

12h25–14h00 **Lunch**

14h00–15h40 **Parallel session - S01**

- D. Vavilov, *Partial Banana Mapping: search for close encounters and impact probability*
- L. Benet, *Transversal Yarkovsky acceleration for Apophis exploiting automatic differentiation tools*
- Ch. Lhotka, *On the Celestial Dynamics of Charged Dust in the Solar System*
- D. Ragozzine, *Non-Keplerian Motion of Trans-Neptunian Binaries: Shapes, Spins, and Formation*
- E. Pilat-Lohinger, *Inward and outward scattering of Oort cloud comets due to Gliese 710*

14h00–15h40 **Parallel session - PA02**

- B. Kumar, *Europa-Induced Overlapping of Secondary Resonances in the 4:3 Jupiter-Ganymede Unstable Resonant Orbit Family*
- A. Rodriguez, *Mapping the structure of the planetary 2:1 mean motion resonance: the TOI-216, K2-24, and HD27894 systems*
- G. Pucacco, *Normal forms for Laplace-like resonances*
- S. Gomes, *The passage through the 5:3 resonance between Ariel and Umbriel with inclination*
- Z. Knežević, *Secular resonance maps*

15h40–16h20 **Coffee Break**

16h20–17h00 **Parallel session - S01**

- S. Dermott, *Asteroid family membership in the inner belt*

- B. Sicardy, *Resonances around small bodies of the solar system: where should be the rings?*

16h20–17h00 **Parallel session - PA02**

- E. Kokubo, *Orbital Architecture of Planetary Systems Formed by Gravitational Scattering and Collisions*
- J. Mah, *Forming Super-Mercuries: Role of stellar abundances*

18h00–20h00 **Welcome Reception** - Boat tour

TUESDAY 4

9h00–9h40 M. Granvik, *Destruction mechanisms for near-Earth objects*

9h40–10h20 A. J. Rosengren, *On the Multiscale Astrodynamics of Cislunar xGEO Space*

10h20–11h00 **Coffee break**

11h00–12h20 **Parallel session - S01**

- S. Di Ruzza, *Analysis of co-orbital motion of real asteroid in a medium-term timescale*
- E. Legnaro, *MEO Secular Resonances: Phase Space, Eccentricity Growth and Diffusion of Navigation Satellites*
- G. Lari, *Orbital evolution of the Galilean moons driven by a fast orbital expansion of Callisto*
- C. Grassi, *Revisiting the computation of the critical points of the squared distance between two ellipses with a common focus*

11h00–12h20 **Parallel session - PA02**

- S. Crespi, *Terrestrial Planet formation Simulations: Homogeneous Comparison between Methods*
- Ph. Griveaud, *Migration of giant planets in low viscosity discs and consequences on the Nice model*
- N. Haghighipour, *Secular Resonances and Terrestrial Planet Formation in Planetary Systems with Multiple Stars: Theory and Application*
- G. Pichierri, *Forming the Trappist-1 system in two steps during the recession of the disc inner edge*

12h20–14h00 **Lunch**

14h00–14h40 A. Johansen *Forming planetary systems via pebble accretion*

14h40–15h40 **Round table “Space awareness”**

- A. Rosengren, *Space debris dynamics*
- J.-M. Van Nypelseer, *An initiative in space debris removal*
- D. Hestroffer, *Hazardous asteroids and the Hera mission*

C. Linard, *Mapping population from space*
Y. Nazé, *Food for thought*

15h40–16h20 **Coffee Break**

16h20–17h00 **Parallel session - S01**

- M. Rossi, *Dynamical asymmetries for L_4/L_5 captures*
- G. Tommei, *On the predictability horizon in Impact Monitoring of NEOs*
- N. Torii, *Gap Structure Created by Satellite Embedded in Saturn's Ring*
- J. Li, *An overview of the high-inclination resonant population in the Kuiper belt*

16h20–17h00 **Parallel session - PA02**

- A. Courtot, *Chaos in meteor showers: the example of Draconids, Leonids and Taurids*
- Al. Petit, *Challenges of the catalogue building and maintenance based on optical survey of the LEO region*
- M. Romano, *Network perspective to study the state of Earth's orbital traffic*
- M. Farhat, *The Impact of Laplace Surface Dynamics on Debris Disc Architecture*
- A. Dgokas, *Secular evolution of debris in highly eccentric and inclined orbits*
- A. Celletti, *SIMPRO: a simulator of breakup events and propagation of orbits of space debris*

WEDNESDAY 5

9h00–9h40 C. Gales, *Dynamics modelling and stability analysis of satellites orbiting oblate bodies*

9h40–10h00 **Poster flash talks 1-20**

10h00–11h00 **Poster session & coffee break**

11h00–11h40 K. Batygin, *Towards a Unified Model of Planet Formation*

11h40–12h20 D. Lay, *Hot Jupiters and Super-Earths: Spin-Orbit Puzzles in Exoplanetary Systems*

12h25–14h00 **Lunch**

14h00–14h40 E. Bolmont, *A journey from planets to stars: improving tidal models in orbital evolution codes*

14h40–14h50 A few words by Anne

14h50–15h50 **Parallel session - S01**

- C. Charalambous, *Tidal effects in resonant chains of close-in planets*
- A. Revol, *Dynamical evolution and heat dissipation in the Trappist-1 system*

- T. Ghosh, *Dynamical Instabilities and the Orbits of Kepler's Multis*

14h50–15h50 **Parallel session - PA02**

- M. Yseboodt, *Mars rotational elements and their quadratic behavior*
- M. Saillenfest, *Oblique rings as a natural end state of migrating exomoons*
- X. J. Xi, *Analytical representation for the numerical ephemeris of Titan within short time spans*

15h50–16h30 **Coffee Break**

16h30–17h30 **Parallel session - S01**

- A. Leleu, *Recovery and characterisation of resonant terrestrial planets hidden in transit surveys*
- J. Korth, *Hot Jupiters and their nearby surroundings*
- Th. Baycroft, *The BEBOP search for circumbinary planets in radial velocity*

20h00–22h00 **Vera Rubin show - Le Delta**

THURSDAY 6

9h00–9h40 G. Baù, *Alternative state representations for orbit prediction*

9h40–10h00 **Poster flash talks 21-36**

10h00–11h00 **Poster session & coffee break**

11h00–12h20 **Parallel session - S01**

- M. Efroimsky, *Pathways of Survival of Exomoons and Inner Exoplanets*
- N. Georgakarakos, *Dynamical habitable zones for circumbinary planets.*
- V. Christiaens, *A new directly imaged giant planet*
- Y. Suto, *Dynamics of a triple system comprising an inner binary black hole in a mutually inclined orbit.*

11h00–12h20 **Parallel session - PA02**

- S. Hadden, *Celestial Mechanics with the celmech code*
- J. Daquin, *Quantifying chaos with geometrical indicators*
- F. Gronchi, *Initial orbit determination from one position vector and a very short arc of optical observations*
- D. Hernandez, *Switching integrators reversibly in the astrophysical N-body problem*

12h20–14h00 **Lunch**

14h00–14h40 C. Dorn *Planet cores store majority of planetary water budgets*

14h40–15h40 **Round table “Habitability”**

- E. Bolmont, *Habitable worlds and climate*
- M. Gillon, *Future detections of habitable worlds*
- E. Javaux, *From early Life to Habitability*
- V. Debaille, *Life and meteorites*
- B. Hespels, *Rotifers in space*

15h40–16h20 **Coffee Break**

16h20–17h00 A. Correia, *New methods to study the tidal evolution of planetary systems*

17h00–17h40 R.-M. Baland, *The obliquity of Mercury: Models and interpretation*

19h00–22h00 **Gala dinner** - Brasserie François

FRIDAY 7

9h00–9h40 J.-B. Delisle, *Planetary systems in resonant chains*

9h40–10h20 C. Petrovich, *Long-term evolution of exoplanet systems*

10h20–11h00 **Coffee break**

11h00–12h20 **Parallel session - S01**

- F. Mogavero, *Timescales of chaos in the inner Solar System: Lyapunov spectrum and quasi-integrals of motion*
- R. Mastroianni, *The phase-space architecture in the secular 3D planetary three-body problem*
- N. Todorović, *Encounter manifolds in the Solar System. Preliminary results*
- T. Hayashi, *Lagrange stability of triple systems: disruption timescale distribution and its dependence on the orbital parameters*

11h00–12h20 **Parallel session - PA02**

- J. Requier, *Resonantly amplified tidal dissipation in the fluid layers of planets and moons*
- F. Zoppetti, *Tidal orbital evolution of circumbinary planets*
- E. Valente, *Excitation of the obliquity of Earth-like planets via tidal forcing*
- A. Coyette, *Cassini States of Ganymede and Callisto*

12h20–14h00 **Lunch**

14h00–14h40 A. Petit, *Long-term stability of compact planetary systems*

14h40–15h20 N. Rambaux, *Lunar reference system from science to MoonLight and LunaNet*

15h20–16h00 **Coffee Break**

16h00–16h40 M. H. Lee, *Dynamics of Circumstellar Planets in Binary Star Systems*

16h40–17h20 J. Laskar, *The AstroGeo project*

17h20-17h30 **Closing Remarks**

	Monday	Tuesday	Wednesday	Thursday	Friday			
8h	REGISTRATION	REGISTRATION	REGISTRATION	REGISTRATION	REGISTRATION			
9h	OPENING SESSION	GRANVIK	GALES	BAU	DELISLE			
9h20		ROSENGREN	Poster flash talks	Poster flash talks	PETROVICH			
9h40	MORBIDELLI							
10h00								
	COFFEE BREAK	COFFEE BREAK	COFFEE BREAK + POSTERS	COFFEE BREAK + POSTERS	COFFEE BREAK			
11h00	SCHERES	Di Ruzza	Crespi	BATYGIN	Efroimsky	Hadden	Mogavero	Rekier
11h20		Legnaro	Griveaud		Georgakarakos	Daquin	Mastroianni	Zoppetti
11h40	FABRYCKY	Lari	Haghighipour	LAI	Christiaens	Gronchi	Todorović	Valente
12h00		Grassi	Pichierri		Suto	Hernandez	Hayashi	Coyette
	Observatory (5 min)							
	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH			
14h00	Vavilov	Kumar	JOHANSEN	BOLMONT	DORN	PETIT		
14h20	Benet	Rodriguez						
14h40	Lhotka	Pucacco	Round-table	A few words by Anne	Round-table	RAMBAUX		
15h00	Ragozzine	Gomes	Space Awareness	Charalambous	Yseboodt	Habitability		
15h20	Pilat	Knežević		Revol	Saillenfest			
				Ghosh	Xi			
	COFFEE BREAK	COFFEE BREAK			COFFEE BREAK	COFFEE BREAK		
16h20	Dermott	Kokubo	Rossi	Courtot		CORREIA		
16h40	Sicardy	Mah	Tommei	Petit (AI)	Leleu	LASKAR		
17h00			Torii	Romano	Korth			
17h20			Li	Farhat	Baycroft	BALAND		
17h40				Dogkas				
18h				Celletti				
	WELCOME RECEPTION 18h-20h BOAT TOUR			VERA RUBIN SHOW 20h	GALA DINNER 19h			
	OBSERVATORY			OBSERVATORY				

SMALL BODIES DYNAMICS	RESONANCES
SPACE DEBRIS	EXOPLANETS
ROTATION	LONG-TERM EVOLUTION & STABILITY
FORMATION	NUMERICAL METHODS

Complex Planetary Systems II – Kavli-IAU Symposium 382 – July 3-7, 2023

Invited talks

Baland	Rose-Marie	The obliquity of Mercury: Models and interpretation
Batygin	Konstantin	Towards a Unified Model of Planet Formation
Bau	Giulio	Alternative state representations for orbit prediction
Bolmont	Emeline	A journey from planets to stars: improving tidal models in orbital evolution codes
Correia	Alexandre	New methods to study the tidal evolution of planetary systems
Delisle	Jean-Baptiste	Planetary systems in resonant chains
Dorn	Caroline	Planet cores store majority of planetary water budgets
Fabrycky	Daniel	Resonant Chain Dynamics: Interpretation of Observations
Gales	Catalin	Dynamics modelling and stability analysis of satellites orbiting oblate bodies
Granvik	Mikael	Destruction mechanisms for near-Earth objects
Johansen	Anders	Forming planetary systems via pebble accretion
Lai	Dong	Hot Jupiters and Super-Earths: Spin-Orbit Puzzles in Exoplanetary Systems
Lee	Man Hoi	Dynamics of Circumstellar Planets in Binary Star Systems
Morbidelli	Alessandro	Interdisciplinarity: an effective approach to comprehending the formation of planetary systems
Petit	Antoine	Long-term stability of compact planetary systems
Petrovich	Cristobal	Long-term evolution of exoplanet systems
Rambaux	Nicolas	Lunar reference system from science to MoonLight and LunaNet
Rosengren	Aaron Jay	On the Multiscale Astrodynamics of Cislunar xGEO Space
Scheeres	Daniel	Binary Asteroids: A Pathway to Understanding the Morphological Evolution of Rubble Pile Asteroids

Sessions:

SMALL BODIES DYNAMICS

SPACE DEBRIS

ROTATION

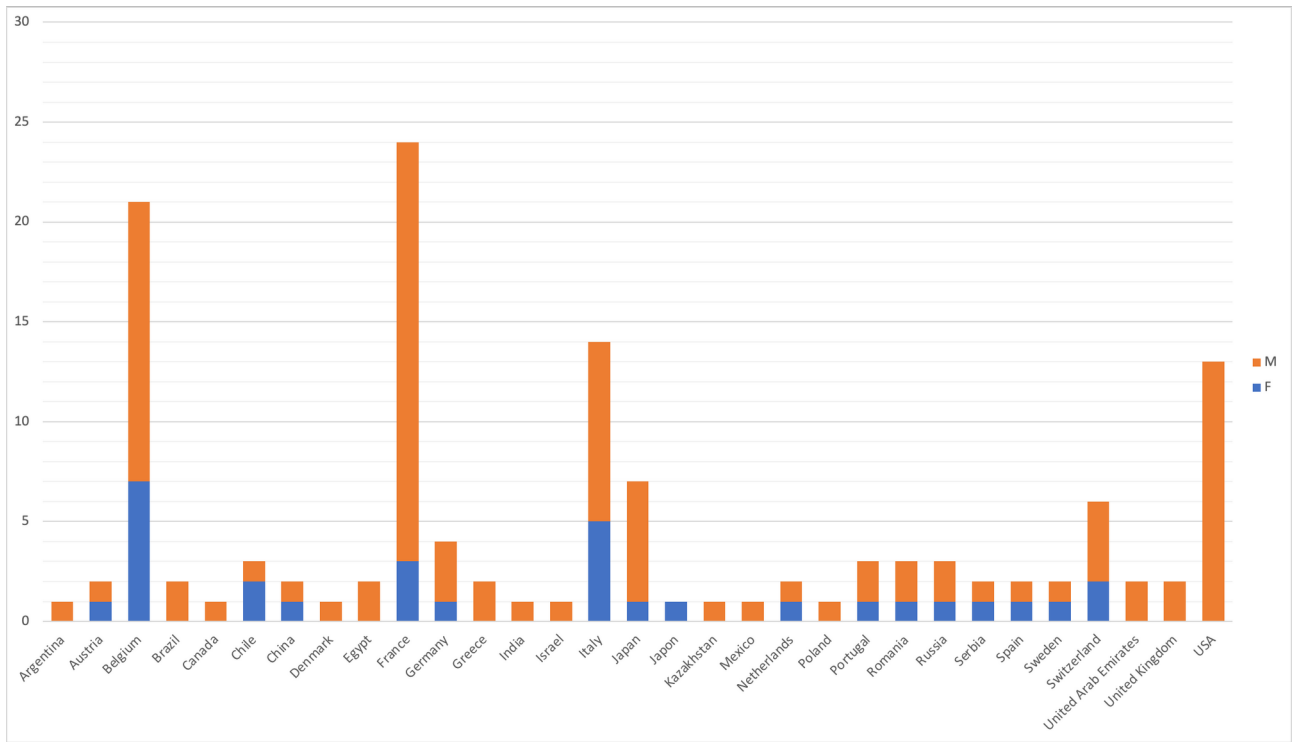
FORMATION

RESONANCES

EXOPLANETS

LONG-TERM EVOLUTION & STABILITY

NUMERICAL METHODS



Scientific highlights of the meeting

The IAU Symposium IAUS-382 was entitled *Complex Planetary Systems II*, or shortly CPSII. It was the second edition, the first one being organized in Namur in July 2014 (IAUS-310). The subtitle chosen for this second edition was *Latest methods for an interdisciplinary approach*. The Kavli label was attributed to the symposium and contributed to reinforce and develop the (already present) interdisciplinarity of the topic.

By definition, complex systems are systems composed of interacting parts/agents whose local behavior, resulting from the interactions between them, cannot provide a complete understanding of the global behavior, i.e. when the system is considered as a whole, on a macroscopic scale. Several levels of description/modeling of the system should be considered at the same time. This forces complex systems to be studied by transdisciplinary teams, able to understand the whole construction and critically analyze the connections among the description levels. This vision is really efficient and challenging for space and astronomy sciences.

Indeed, the huge number of available observations (from ground and space) and their accurate precision, as well as the computational power and speed of our present-day computers have spectacularly changed the nature of the dynamical models, especially for planetary evolution studies. Planetology, celestial mechanics, cosmology, space geodesy have considerably evolved in that direction during the last decade, and have reinforced the need for crossing experiences and methods. Let us mention several examples: the concept of habitability of an extrasolar planet, the dynamical history of the Solar System and other planetary systems, the rotation of planets and satellites linked to their internal structure, the motion of natural satellites needing astrometry, tides and dissipations, the thermal effects on the evolution of the rotating small asteroids, the long term evolution of space debris and satellites, including drags, shadowing effects, collisional chain reactions. All these problems as well as many others were tackled at CPSII, showing how the formal historical border between analytical and numerical approaches has now disappeared.

The symposium was a real opportunity to show the power of interdisciplinary collaboration and was a unique occasion to gather astronomers of many disciplines together. While the global thematic remained the planetary systems as in the first edition, CPSII highlighted that first, the tools and the methods have considerably evolved, and second, the interdisciplinarity has touched more communities. Also the organization of the meeting was innovative, with a priority to young promising speakers, on interdisciplinary topics, two round tables on space awareness and habitability, poster flash talks with different prizes awarded to the best poster presentations. CPSII opened new doors and created collaborations, exchanges of ideas, combinations of techniques, sometimes unexpected, to solve complex planetary systems.

The symposium brought together 132 scientists, from 30 different countries, and proposed a challenging program, with 19 invited speakers, 57 talks and 33 posters. The scientific communities on the Solar system and the exoplanets, were particularly happy to meet again after the pandemic. It was a great success in terms of contacts, discussions and new projects.

Executive summary

The meeting was a success, with 140 (finally 132 present) participants, coming from 30 different countries. Several sponsors contributed to the success of the event: IAU and Kavli supports, FNRS and UNITER, UNamur, Fonds Jacques Cox pour les Générations Futures.

The programme included the following 8 sessions, namely

- Small bodies dynamics,
- Dynamics of space debris,
- Rotation of planets and satellites,
- Formation of planetary systems,
- Dynamics of resonances and observations,
- Exoplanets, climate and interiors,
- Long-term evolution and stability of planetary systems,
- Numerical methods.

One, two or three key speakers were invited for each session. The 19 key speakers were selected among the promising scientists of the different fields, with a special attention to recent and innovative research, as well as geographical and gender balance. They were all invited to give a talk of 30 minutes (followed by 10 minutes of questions) and to emphasize the interdisciplinary aspects of their results.

The KAVLI label was the opportunity to enlarge the scope of the symposium, with additional contributions of scientists from close fields, as geologists, biologists, geographers, applied mathematicians, observers, and engineers.

After a welcome message from the authorities of UNamur and the naXys Research institute (organizers), the opening session consisted in the conference of A. Morbidelli (Observatoire de la Côte d'Azur) entitled *Interdisciplinarity: an effective approach to comprehending the formation of planetary systems*. The topic was very representative of the spirit of the symposium: it is impossible to solve a real astronomical problem without considering its full complexity and interdisciplinary.

The SOC selected 57 talks with a duration of 15 minutes; the questions were numerous and very interesting, giving suggestions for future works or comparisons. The majority of the presentations consisted of very recent research works (published in the year or only submitted). The two long coffee breaks a day were the occasion for open discussions, comments, and questions, and this opportunity was greatly appreciated by the participants.

In the spirit of KAVLI, two round tables were proposed, one on *Space awareness* and the other one on *Habitability*, with contributors from UNamur scientists, Belgian university colleagues and astronomers, and representatives of the sponsors, all with totally different backgrounds. This innovative way of discussing a topic through different disciplines, was a nice opportunity to cross the boundaries, compare the points of view, and connect researchers with different expertise.

33 posters (proposed by 31 scientists) were exhibited the whole week; the researchers summarized their results during two flash talk sessions (*one slide, one minute*). Prizes for the best posters were awarded to four participants, two in the category *Space Awareness* and two in *Complex Planetary Systems*.

Several social events were proposed, well appreciated by the participants: the welcome reception on a boat tour (3/7), the Vera Rubin dance and theater show about the life of the astrophysicist Vera Rubin (5/7), the guided underground tour of the citadel of Namur, the visit of the UNamur observatory, and the gala dinner (6/7) during which the poster prizes were announced. An invitation to the welcome session and the two round tables was also sent to all the university members, while a Space quizz outreach activity was organized (in French) for the citizens of Namur (8/7).