

## COMMISSION A4

## CELESTIAL MECHANICS AND DYNAMICAL ASTRONOMY

*MÉCHANIQUE CÉLESTE ET  
ASTRONOMIE DYNAMIQUE*

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## TRIENNIAL REPORT 2018-2021

### 1. Background

Celestial Mechanics and Dynamical Astronomy aim at investigating the dynamics of N-body systems under gravitational interaction. The possible objects of study can be either natural bodies of the Solar system (planets, satellites, asteroids, etc.), artificial satellites, extra-solar planetary systems, star clusters, galaxies. During the last decades, several discoveries took place that reinvigorated this discipline: extrasolar planets, KBOs, NEOs, low-energy interplanetary trajectories, space debris. Such discoveries are accompanied by an increased amount of available observational data and by increasing computational capabilities, which include parallel computing and machine learning techniques. All these ingredients contributed to drastic changes in the procedures of investigation of the dynamics of celestial objects.

### 2. Developments within the past triennium

The main objectives of the IAU Commission A4 Celestial Mechanics and Dynamical Astronomy are to support research and training activities. Research in Celestial Mechanics and Dynamical Astronomy consists in the accurate modeling of relevant physical problems, and a detailed study of their mathematical, physical and computational aspects. A non exhaustive list of the main topics includes N-body systems, ring models, tidal effects, general relativistic effects, galactic dynamics, non-gravitational forces. The analytical and numerical methods used in Celestial Mechanics and Astrodynamics include perturbation theory, dynamical systems techniques, chaos detection, data analysis, computer studies.

The Committee A4 promotes the dissemination of Celestial Mechanics and Dynamical Astronomy through several means: scientific conferences, workshops, schools. In particular, the CELMEC meetings are held every 4 years since 1993 (commonly recognized as a reference point for researchers in the field).

Over the past triennium, members of Committee A4 co-organized the following events:

- “New Trends in Celestial Mechanics”, Cogne, Valle d’Aosta, Italy, June 24-28, 2019;
- “I-CELMECH Training School”, Milano, Italy, 3-7 February, 2020. Lectures and talks are available at [http : //www.mat.unimi.it/I-CELMECH/index.php/training-school – lectures – talks/](http://www.mat.unimi.it/I-CELMECH/index.php/training-school-lectures-talks/); most of the lectures appear in the book edited by Baú & al (2021);
- “Stardust-R Global Virtual Workshop”, Pisa, Italy, 7-10 September, 2020;
- “Stardust-R Network Training School “Space environment stability and resilience””, Iasi, Romania, 15-19 March 2021.

Members of Committee A4 promote special issues in peer-reviewed international journals. In particular, past and on-going calls for topical collections in the journal “Celestial Mechanics and Dynamical Astronomy” are the following:

- Trans Neptunian Objects;
- Toward the Moon and Beyond;
- Exoplanet Dynamics;
- Main Belt Dynamics.

The Commission is also in charge of periodically sponsoring and/or co-sponsoring the organization of IAU symposia. Members of Committee A4 are organizing the IAU Symposium 364 “Multi-scale (time and mass) Dynamics of Space Objects” in Iasi, Romania, 18-22 October 2021 (initially scheduled in July 2020, it has been postponed to October 2021 due to the pandemic situation).

The Symposium aims to cover the recent advances in the multi-scale dynamics of natural and artificial space objects under different perspectives: modelling, new dynamical methods and tools, stability analysis, exploration and exploitation of minor bodies. The Symposium will act as a bridge within a wide international community working in various fields: physics, celestial mechanics, astrodynamics, planetary sciences, space engineering, applied mathematics, dynamical systems. The Symposium will provide a venue for interdisciplinary discussions, exchanging ideas, making future plans and developing new collaborations.

A ResearchGate project called “Celestial Mechanics and Dynamical Astronomy” has been established to foster an efficient information system with the aim to facilitate the collaboration among the researchers working in these disciplines. At the moment, the project counts 178 followers and 6846 reads since January 2017.

The Committee A4 always maintains a fruitful cooperation with other Commissions of the IAU, and also in diverse fields of science such as applied mathematics, mathematical physics, geophysics, space sciences, whose research is often applicable to astronomical problems.

### 3. Conclusion and future plans

In the incoming triennium, a key activity will be the proposal for the formation of working groups to monitor progress in the main research directions of Celestial Mechanics and Dynamical Astronomy. Exploiting the possibilities offered by art.24, par. VI of the IAU Bylaws, the Commission will ask Divisions approval on the setting of three-year working groups in key domains related to the mathematical, physical and computational aspects of solar and extrasolar system dynamics, astrodynamics and space mechanics, orbits in general relativity, orbits in gravitational systems such as clusters and galaxies. The aim of each approved working group will be to continuously monitor progress and to provide reporting to the Commission of the most important advancements to key open

problems in the above fields. The reports of the working groups will be included in the reporting (annual or three-year) of the executive committee.

The Commission and its members will also continue to work on the expansion of the projects established by the 2018-2021 executive committee, in particular the support and expansion of the quite successful ResearchGate project “Celestial Mechanics and Dynamics Astronomy” and the collaboration with other IAU Commissions working on adjacent subject areas. Commission A4 will also continue to support high-quality schools and future editions in incoming years.

Finally, an important task, steered by the executive committee, will be to identify and invite to IAU (and Commission) membership new researchers, working on the A4 Commission subject areas, who are currently not members of the IAU.

Alessandra Celletti  
*President of the Commission*

## References

Baú, G. & Di Ruzza, S. & Paez, R.I. & Penati, T. & Sansottera, M. (eds.) 2021, *New frontiers of Celestial Mechanics: theory and applications* (Springer Proceedings in Mathematics & Statistics (PROMS))