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PREFACE

Topical collection "50 years of Celestial Mechanics and Dynamical Astronomy"

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The topical collection "50 years of Celestial Mechanics and Dynamical Astronomy" has been proposed to celebrate the anniversary of the publication of its first issue in March 1969.

The first edition of the journal was published under the title "Celestial Mechanics" as an initiative of the Celestial Mechanics Institute. Later in 1989, the journal changed its name into "Celestial Mechanics and Dynamical Astronomy" (CM&DA). Over the years the editors-in-chief, associate editors and authors made a big effort to keep the journal up-to-date and retain a high scientific standard.

As written in 1990 by J.M.A. Danby ([CMDA 1990, vol. 50, 5–6]), the birth of the journal "Celestial Mechanics" dates back to a meeting at the Goddard Space Flight Center. The editorial of the first issue, while defining Celestial Mechanics as an old science that infers or proves "physical facts from the study of orbital behavior and other phenomena exhibited by celestial and artificial bodies," underlined the need for research in this field, also due to the number of questions raised by the international space programs. A requirement raised at that time, and still valid nowadays, was to satisfy "accuracy, computational adaptability and speed." Indeed, over the last decades space missions and scientific discoveries have contributed to give answers, but also to raise new questions, thus making Celestial Mechanics an evergreen field of research. Among the relatively recent findings, we would like to mention the discovery of the Kuiper belt at the edge of the Solar system, the detection of extra-Solar planetary systems, the visionary concept of interplanetary highways that gave rise to a new branch of Astrodynamics, now known as "Space Manifold Dynamics."

The first issue of CM&DA dealt with topics that are still fully up-to-date; a partial list contains the critical inclination problem, perturbation theories, rotational dynamics, artificial satellite motions, orbit determination. Nowadays, these are among the most timely topics on which many researchers concentrate. It might therefore seem surprising that such topics appeared already in the journal in March 1969.

This fact highlights that Celestial Mechanics is often characterized by two main aspects: on one side, many topics are timeless despite the technological advancements, and on the other hand, some problems exhibit an intrinsic difficulty which covers centuries of research

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studies (like the celebrated 3-body problem). Indeed, Celestial Mechanics as well as Dynamical Astronomy are based on a complex recipe that mixes together three main ingredients: the construction of models that accurately describe space problems, the development of mathematical theories to study (complex) models, a wide range of applications to natural and artificial objects of the Solar system.

Over the last 50 years, the journal CM&DA has become a reference point for all researchers working in the field. The articles of CM&DA have covered a wide range of topics that definitely satisfy all scientific tastes: from the motion of artificial objects to that of natural bodies, from numerical simulations to advanced mathematical theories. It is important to stress that Celestial Mechanics brings novelties in several directions; it might contribute to create a new model, develop an innovative theory, make a forefront application or rather create a new paradigm that, mixing all three ingredients, leads to original, possibly visionary, ways to study the motion of the celestial bodies.

In this scientific and cultural context, it is worth recalling the words that ended the editorial of the first issue in March 1969 (we just update of the name of the journal): "if each of us will contribute a little, not only to Celestial Mechanics (the field) but also to 'Celestial Mechanics' (the journal), each will benefit and realize some degree of personal satisfaction in knowing that we have helped through our contributions."

The topical collection "50 years of Celestial Mechanics and Dynamical Astronomy" contains 19 articles which cover different subjects. We shortly summarize here their content.

The article by Scheeres (vol. 132, article n. 4) concerns the analysis of the energy required for collections of finite-density bodies to undergo escape under internal gravitational interactions alone; the results provide also information for the disruption of rubble-pile asteroids when only considering gravitational interaction effects. The article by Pfenniger (vol. 131, article n. 58) derives four expressions, depending on sums of position and velocity coordinates, which bound the total angular momentum of particle systems or, by extension, of any continuous or discontinuous material systems.

Central configurations have been considered in the articles by Hampton (vol. 131, article n. 20) and by Corbera et al. (vol. 131, article n. 34); in the former paper, the author computes bounds on the eigenvalues for the regular polygon with equal masses and gives estimates on where bifurcations occur, while in the latter paper, the authors classify the full set of convex central configurations in the Newtonian planar four-body problem.

Mean-motion resonances are dealt by Sansottera and Libert (vol. 131, article n. 38) and Lhotka and Gales (vol. 131, article n. 49). In the first paper, the Lagrange–Laplace secular approximation for coplanar systems has been studied to analyze the dynamics of resonant extra-Solar systems; in the second paper, the authors investigate the dynamics of charged dust close to outer mean-motion resonances with Jupiter.

The Lambert problem is the subject of the articles by Albouy (vol. 131, article n. 40) and Russell (vol. 131, article n. 50). The paper by Albouy gives two new proofs of Lambert theorem on the elapsed time along a Keplerian arc, using Hamilton's variational proof and using Lambert's geometrical proof. The paper by Russell considers several aspects of the multiple-revolution Lambert problem (e.g., parameter and solution space, problem domain, interpolation of the Lambert iteration variable).

Satellite theories have been investigated in the article by Mahajan and Alfriend (vol. 131, article n. 45), where the authors give the mathematical development of a first-order orbit theory, which includes a complete gravitational potential with all zonal, sectorial and tesseral harmonics considered as the dominant perturbations. The article by Lara (vol. 131, article n. 42) considers the main problem of artificial satellite theory and develops a new radial, natural, higher-order intermediary using a suitable Lie transforms simplification. Perturbations due to planetary oblateness, together with Solar radiation pressure, have been considered by Alessi et al. (vol. 131, article n. 43) with the aim to characterize the equilibrium points and the phase space associated with the singly averaged dynamics. The comparison of semi-analytical and non-averaged propagation methods for Earth's satellite orbits is performed in the article by Amato et al. (vol. 131, article n. 21) as an alternative to semi-analytical orbit propagation methods.

Going farther from the Earth, the articles by Jorba and Jorba-Cuscó (vol. 132, article n. 11) and by Pucacco (vol. 131, article n. 44) deal with the collinear libration points. In the first article, the authors study the bicircular problem and, using a periodic time-dependent reduction to the center manifold, they show the existence of two families of (planar and vertical) quasi-periodic Lyapunov orbits. The paper by Pucacco provides a global analysis of the center manifold of the collinear points within the circular restricted three-body problem; bifurcation sequences of the main orbit families are studied using a geometric theory based on the reduction of the symmetries of the normal form.

The article by Miguel and Colombo (vol. 131, article n. 59) concerns the coupled attitude and orbit dynamics of Solar sails, where the sail is assumed to be a simplified quasi-rhombic pyramid that provides the structure helio-stability properties. An approximate analytical solution for the two-body problem perturbed by a radial, low thrust is obtained in the article by Gonzalo and Bombardelli (vol. 131, article n. 37), where they use a regularized formulation of the orbital motion and the method of multiple scales.

The B-plane formulation is the subject of the article by Farnocchia et al. (vol. 131, article n. 36): this tool is fundamental to study planetary encounters of small bodies and spacecraft flybys; under linearity assumptions, the authors show how to derive close approach boundaries and impact probabilities from the orbital uncertainty mapped onto the B-plane.

The article by Boué and Efroimsky (vol. 131, article n. 30) formulates the expressions for the rates of the Keplerian orbital elements within a two-body problem perturbed by the tides in both partners, providing a complete derivation, from scratch, of these rates.

The article "Are the analytical proper elements of asteroids still needed?" by Knezevich and Milani (vol. 131, article n. 27) deserves special mention. Our friend and colleague Andrea Milani passed away in November 2018; this makes this article and the whole topical collection extremely valuable. Their results set up the question mark appearing in the title and clearly confirm the superior quality of synthetic values; the authors also present a new synthetic method to determine the locations of secular resonances.

We would like to thank all authors for their contributions. We also recognize the members of the editorial board for their continuous work to promote the journal.

A special thanks to the members of the committee that selected the articles included in this topical collection: C. Beaugè, B. Erdi, T. Fukushima, G. Gomez, P. Gurfil, A. Lemaitre, V. Sidorenko. We are also grateful to Frank Schulz for his accurate and continuous editorial assistance.

We hope that our readers will enjoy reading the articles of the topical collection "50 years of Celestial Mechanics and Dynamical Astronomy," which witness the past and present status of the researchers working in Celestial Mechanics and Astrodynamics: a lively, cohesive and growing community.