

COMPLEX PLANETARY SYSTEMS

IAU SYMPOSIUM No. 310

COVER ILLUSTRATION:

IAU Symposium 310 takes a broad look at the complexity of planetary systems, in terms of the formation and dynamical evolution of planets, their satellites, minor bodies and space debris, as well as to the habitability of exoplanets, in order to understand and model their physical processes. The main topics covered are diverse, including: studies of the rotation of planets and satellites, including their internal structures; the long term evolution of space debris and satellites; planetary and satellite migration mechanisms; and the role of the Yarkovsky effect on the evolution of the rotating small bodies. Intended for researchers and advanced students studying complex planetary systems, IAU S310 appeals to non-specialists interested in problems such as the habitability of exoplanets, planetary migration in the early Solar System, or the determination of chaotic orbits. This volume provides a valuable insight into the state-of-the-art research in this exciting interdisciplinary field.

IAU SYMPOSIUM PROCEEDINGS SERIES

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Table of Contents

Preface	ix
The Organizing Committee	xi
Conference Photograph	xii
Participants	xiii

Rotation of the bodies

The libration and interior structure of large icy satellites and Mercury <i>T. Van Hoolst</i>	1
Spin-orbit resonances and rotation of coorbital bodies in quasi-circular orbits <i>P. Robutel, A. C. M. Correia & A. Leleu</i>	9
A supplementary note on constructing the general Earth's rotation theory <i>V. A. Brumberg & T. V. Ivanova</i>	13
New clues on the interior of Titan from its rotation state <i>B. Noyelles & F. Nimmo</i>	17
Complements to the longitudinal librations of an elastic 3-layer Titan on a non-Keplerian orbit <i>A. Richard & N. Rambaux</i>	21
The long-period forced librations of Titan <i>M. Yseboodt & T. Van Hoolst</i>	25
Scaling laws to understand tidal dissipation in fluid planetary layers and stars <i>P. Auclair-Desrotour, S. Mathis & C. Le Poncin-Lafitte</i>	29
Revisiting the capture of Mercury into its 3:2 spin-orbit resonance <i>B. Noyelles, J. Frouard, V. V. Makarov & M. Efroimsky</i>	33

N-Body problems and algorithms

Variational Chaos Indicators: Application to the Restricted Three-Body Problem <i>A. M. Koxsin & V. A. Shefer</i>	35
The parametric instability of resonance motion in restricted three body problem <i>A. E. Rosaev</i>	39
Three-body problem, the measure of oscillating types. A short review <i>C. Marchal</i>	43
The special case of the three body problem, when gravitational potential is given as the Kislik potential <i>A. Shuvalova & T. Salnikova</i>	45

Dynamics of exoplanets

On the orbital structure of the HD 82943 multi-planet system <i>R. V. Baluev & C. Beaugé</i>	49
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vi	<i>Contents</i>	
Dynamics and Habitability in Binary Star Systems		53
<i>S. Eggl, N. Georgakarakos & E. Pilat-Lohinger</i>		
Tidal evolution in multiple planet systems: application to Kepler-62 and Kepler-186		58
<i>E. Bolmont, S. N. Raymond, J. Leconte, A. Correia & E. Quintana</i>		
Spin-orbit angle in compact planetary systems perturbed by an inclined companion. Application to the 55 Cancri system		62
<i>G. Boué & D. C. Fabrycky</i>		
Pebble Delivery for Inside-Out Planet Formation		66
<i>X. H. Jonathan, C. Tan & S. Chatterjee</i>		
Modeling resonant trojan motions in planetary systems.		70
<i>C. Efthymiopoulos & R. I. Páez</i>		
On the relativistic Lagrange-Laplace secular dynamics for extrasolar systems.		74
<i>M. Sansottera, L. Grassi & A. Giorgilli</i>		
Orbital fitting of Fomalhaut b and subsequent interaction with the dust belt		78
<i>H. Beust, V. Faramaz & J.-C. Augereau</i>		
1/1 resonant periodic orbits in three dimensional planetary systems		82
<i>K. I. Antoniadou, G. Voyatzis & H. Varvoglis</i>		
PlanetPack software tool for exoplanets detection: coming new features		84
<i>R. V. Baluev</i>		
Impact flux of asteroids and water transport to the habitable zone in binary star systems		86
<i>D. Bancelin, E. Pilat-Lohinger, S. Eggl & R. Dvorak</i>		
Eccentricity estimates in hierarchical triple systems		88
<i>N. Georgakarakos & S. Eggl</i>		
Understanding the assembly of <i>Kepler's</i> tightly-packed planetary systems.		90
<i>T. O. Hands, R. D. Alexander & W. Dehnen</i>		
Empirically Derived Dynamical Models for the 55 Cancri and GJ 876 Planetary Systems		93
<i>B. E. Nelson, E. B. Ford, J. T. Wright & D. A. Fischer</i>		
Modeling Trojan dynamics: diffusion mechanisms through resonances		96
<i>R. I. Páez & C. Efthymiopoulos</i>		
Diagrams of stability of circumbinary planetary systems		98
<i>E. Popova</i>		
Transit observations with the three San Pedro Mártir telescopes		101
<i>D. Ricci, M. Reyes-Ruiz, R. Michel, C. Ayala-Loera, G. Ramón-Fox, L. F. Machado, S. Navarro, S. Brown Sevilla & S. Curiel</i>		
Dynamic study of possible host stars for extrasolar planetary systems.		104
<i>N. A. Shakht, L. G. Romanenko, D. L. Gorshanov & O. O. Vasilkova</i>		
Symmetric Four-mass Schubart-like Systems.		106
<i>W. L. Sweatman</i>		

Contents

vii

Small bodies, asteroids and space debris

Small asteroid system evolution	108
<i>S. A. Jacobson</i>	
Ranking in-orbit fragmentations and space objects.	118
<i>A. Rossi, G. B. Valsecchi & E. Maria Alessi</i>	
Dynamical evolution of near-Sun objects.	126
<i>V. V. Emel'yanenko & M. A. Shelyakov</i>	
Automated Classification of Asteroids into Families at Work.	130
<i>Z. Knežević, A. Milani, A. Cellino, B. Novaković, F. Spoto & P. Paolicchi</i>	
Hill Stability in the Full 3-Body Problem	134
<i>D. J. Scheeres</i>	
Fragmentation of colliding planetesimals with water content.	138
<i>T. I. Maindl, R. Dvorak, C. Schäfer & R. Speith</i>	
Trajectory and physical properties of near-Earth asteroid 2009 BD	142
<i>D. Farnocchia, M. Mommert, J. L. Hora, S. R. Chesley, D. Vokrouhlický, D. E. Trilling, M. Mueller, A. W. Harris, H. A. Smith & G. G. Fazio</i>	
Orbit computation of the TELECOM-2D satellite with a Genetic Algorithm . . .	146
<i>F. Deleflie, D. Coulot, A. Vienne, R. Decosta, P. Richard & M. Amjad Lasri</i>	
New methods for space debris collision assessment.	150
<i>D. Casanova, C. Tardioli & A. Lemaître</i>	
Comparison of different methods to compute a preliminary orbit of Space Debris using radar observations	154
<i>H. Ma & G. F. Gronchi</i>	
Orbit identification for large sets of data: preliminary results	156
<i>S. Marò & G. F. Gronchi</i>	
Averaged changes in the orbital elements of meteoroids due to Yarkovsky-Radzievskij force.	160
<i>G. O. Ryabova</i>	
Explosive evolution of small bodies in planetary atmospheres.	162
<i>S. Ibadov & F. S. Ibadov</i>	
Close encounters of Near Earth Objects with large asteroids.	164
<i>A. Ivantsov, S. Eggl, D. Hestroffer, W. Thuillot & P. Gurfil</i>	
Determination of an Intermediate Perturbed Orbit using Multiple Observations	166
<i>V. A. Shefer</i>	
Dynamical evolution of objects on highly elliptical orbits near high-order resonance zones	168
<i>E. D. Kuznetsov & S. O. Kudryavtsev</i>	
On relative equilibria of mutually gravitating massive point and triangular rigid body	170
<i>V. I. Nikonov</i>	
The family of Quasi-satellite periodic orbits in the circular co-planar RTBP. . . .	172
<i>A. Pousse, P. Robutel & A. Vienne</i>	

viii	<i>Contents</i>	
Excluding interlopers from asteroid families		174
	<i>V. Radović & B. Novaković</i>	
The effect of secular resonances on the long-term orbital evolution of uncontrolled near-Earth objects		176
	<i>T. V. Bordovitsyna, I. V. Tomilova & G. O. Ryabova</i>	
Long-term evolution of asteroids in the 2:1 Mean Motion Resonance		178
	<i>D. K. Skoulidou, K. Tsiganis & H. Varvoglis</i>	
Dynamical properties of Watsonia asteroid family		180
	<i>G. Tsirovoulis, B. Novaković, Z. Knežević & A. Cellino</i>	
Solar system and natural satellites		
Complex satellite systems: a general model of formation from rings		182
	<i>A. Crida & S. Charnoz</i>	
Spin-orbit coupling and chaotic rotation for eccentric coorbital bodies.		190
	<i>A. Leleu, P. Robutel & A. C. M. Correia</i>	
On the Lagrange libration points of the perturbed Earth-Moon System		192
	<i>T. V. Salnikova & S. Ya. Stepanov</i>	
Formation of planetary systems		
The Grand Tack model: a critical review		194
	<i>S. N. Raymond & A. Morbidelli</i>	
Planetesimal fragmentation and giant planet formation: the role of planet migration		204
	<i>O. M. Guilera, D. Swoboda, Y. Alibert, G. C. de Elía, P. J. Santamaría & A. Brunini</i>	
Rapid planetesimal formation in the inner protoplanetary disk		208
	<i>J. Drążkowska, F. Windmark & S. Okuzumi</i>	
Effects of planetary mass accretion on the planets migration: the disk structures		212
	<i>R. Álvarez & E. Nagel</i>	
Reversing Type I Migration in Gap Shadows		214
	<i>H. Jang-Condell</i>	
Planet Formation in Close Binaries		216
	<i>H. Jang-Condell</i>	
Terrestrial planet formation in low-mass disks: dependence with initial conditions		218
	<i>M. P. Ronco, G. C. de Elía & O. M. Guilera</i>	
Influence of the inclination damping on the formation of planetary systems		220
	<i>S. Sotiriadis, A.-S. Libert & K. Tsiganis</i>	
Rapid clump formation in discs of young stellar objects class O-I		223
	<i>O. P. Stoyanovskaya & V. N. Snytnikov</i>	
Can we expect the massive discs around young stellar objects class O-I to be a birthplace of planetesimal?		225
	<i>V. N. Snytnikov, O. P. Stoyanovskaya & O. A. Stadnichenko</i>	
Author index		227

Preface

The huge number of available observations (from ground and space) and their high precision, as well as the computational power and speed of the present-day computers have spectacularly changed the nature and the accuracy of the dynamical models, especially for planetary evolution studies. Indeed, any phenomenon, any planetary system, and any n-body problem appears now much more complex than it was originally thought. Consequently, it cannot be described by a simple dynamical model. To provide a complete understanding of the global behavior of the real system, several levels of modeling should be taken into account at the same time.

To unravel the complexity of such systems, to understand the underlying phenomena and to build a model able to reproduce the observations in a realistic way, requires collaboration and interdisciplinarity of scholars from very different fields.

Celestial mechanics has decisively evolved in that direction during the last decade. Our symposium aimed to bring forward these efforts. Thanks to this highly complex analysis, taking into account as many aspects as possible in the models, realistic results are obtained, giving answers to several astronomical questions, especially but not only in planetary sciences.

The results obtained and discussed at the symposium, with this perspective and level of complexity and interdisciplinarity are numerous. Let us mention

- the concept of habitability of a planet, mixing biological and dynamical criteria,
- the studies of the rotation of planets and satellites, requiring data and models of their internal structure and thus interactions with geologists and physicists,
- the understanding of the long term evolution of space debris and satellites, which requires the introduction of drags, frictions or shadowing effects,
- the modeling of migration mechanisms, including the interaction between the planets and the gas and planetesimal disk,
- the discovery of new mechanisms to explain the size, the location and the composition of natural satellites,
- the cascade of resonances and sub resonances necessary to explain a specific observation,
- the role of the Yarkovsky thermal effect on the evolution of the rotating small bodies,
- the NEO chaotic orbit determination used in impact monitoring,
- the development of sophisticated symplectic integrators and of increasingly precise tools for detection and measure of chaos.

All these results have shown the disappearing of the formal historical border between analytical and numerical approaches.

This symposium focused on the main dynamical aspects of planetary science, pointing in each topic to the recent results obtained thanks to the synergy of different disciplines, and to the treatment of the problem in its full complexity.

The speakers (and especially the key speakers) were invited to show results of this interdisciplinary approach, describing the complexity of the system and emphasizing the outcomes of its new description. The SOC gave priority to talks and posters resulting from collaborations between teams and disciplines. The meeting was a success, with 129 participants, coming from 30 different countries. The program was organized in 6 sessions:

- Session 1 : Introduction and motivation
- Session 2 : Rotation, N-Body and algorithms
- Session 3 : Exoplanets

x

- Session 4 : Small bodies (asteroids and space debris)
- Session 5 : Solar System and natural satellites
- Session 6: Formation of planetary systems

The opening session was reserved for the welcoming messages, from the University, from the research center naXys and from the organizers. The formal part was followed by J. Laskar's (IMCCE, Observatory of Paris) plenary talk on *Chaotic diffusion in the Solar System and the astronomical calibration of geological timescale*. This topic was very representative of the spirit of the symposium: it is not possible to solve a real astronomical problem without considering its full complexity and interdisciplinarity.

The choice of the key speakers was especially successful; the SOC wanted to choose the new generation of scientists, and they all answered with enthusiasm, giving excellent, lively and interesting talks (35-40 minutes), well documented and at the top of the present research in the field. T. Van Hoolst for the rotation, C. Beaug and A. Correia for the exoplanets, A. Morbidelli and A. Crida for the Solar system, S. Jacobson and A. Rossi for the small bodies and debris and S. Raymond for the formation of the planetary systems, proved their expertise and communication skills.

The SOC selected 76 contributed talks of 18-20 minutes; the questions that followed the talks were numerous and very interesting, giving suggestions for future work or comparisons. The majority of the presentations referred to very recent research, published this year or even only submitted. The organization of the meeting, with two coffee breaks, allowed to have discussions, give comments and rise questions just after the talks.

58 posters were exhibited during the whole week; the researchers had the possibility to present their results during the related session, in the form *one slide, one minute*. The exercise was interesting, very well used by most of them. Three special prizes were given to the best posters: the first one for the master students (won by D. Skoulidou, from Greece), the second one for the PhD students (won by G. Tsirvoulis from Greece) and the third one for confirmed researchers (won by H. Jang-Condell from USA). The jury was composed of D. Scheeres, D. Hestroffer and M. Yseboodt.

The symposium was held at the premises of the University of Namur, to which the organizers owe a gratitude for the warm hospitality.

Last but not the least, we gratefully acknowledge the support of the sponsors listed on page *xxi* which made this conference possible.

*Anne Lemaître, chair SOC,
Anne-Sophie Libert, chair LOC
Namur, October 10, 2014*

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