H2020 Excellent Science - ERC - 2015 StG Stable and Chaotic Motions in the Planetary Problem



Established by the European Commission



Università degli Studi di Padova

Think Tank on Scientific Computing and Funding Opportunities University of Camerino, June 18 - 19, 2021



European Research Council

Supporting top researchers from anywhere in the world

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H2020 Excellent Science Pillar

1. The European Research Council (ERC) will provide attractive and flexible funding to enable talented and creative individual researchers and their teams to pursue the most promising avenues at the frontier of science, on the basis of Union-wide competition.

2. Future and emerging technologies will support collaborative research in order to extend Europe's capacity for advanced and paradigm-changing innovation. They will foster scientific collaboration across disciplines on radically new, high-risk ideas and accelerate development of the most promising emerging areas of science and technology as well as the Union-wide structuring of the corresponding scientific communities.



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3. Marie Sklodowska-Curie Actions will provide excellent and innovative research training as well as attractive career and knowledge-exchange opportunities through cross-border and cross-sector mobility of researchers to best prepare them to face current and future societal challenges.

4. Research infrastructure (including e-infrastructures) will develop European research infrastructure for 2020 and beyond, foster their innovation potential and human capital, and complement this with the related Union policy and international cooperation.

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ALL ABOUT ERC FUNDING

ERC STARTING GRANTS

Grants up to 1.5€ million for 5 years For promising early-career researchers with 2 to 7 years experience after PhD

ERC ADVANCED GRANTS

Grants up to 2.5€ million for 5 years

For established research leaders with a recognised track record of research achievements

ERC CONSOLIDATOR GRANTS

Grants up to 2€ million for 5 years For excellent researchers with 7 to 12

ERC PROOF OF CONCEPT

years experience after PhD

Lump Sum Grant of 150.000€

For existing ERC grant holders to bring their research ideas closer to market

SYNERGY GRANTS

Grants up to 10€ million for 6 years

To address ambitious research questions that can only be answered by the coordinated work of a small group of 2-4 principal Investigators

ADDITIONAL OPPORTUNITIES

For researchers wishing to work or gain experience in an ERC grantee's team

https://erc.europa.eu/

ERC grants support projects carried out by an individual researcher who can employ researchers of any nationality as team members.

https://erc.europa.eu/funding/starting-grants

ERC offers independence, recognition & visibility

Cristina Gabellieri, Physical and Engineering Sciences, European Research Council





- high visibility:
 - open access for publications;
 - activities published on the website of the project;
 - access to EU platforms ECAS, CORDIS, EURAXESS, ...
- scientific independence:
 - team members are free of establishing their own scientific collaborations and research activities, in order to reach the scientific objectives of the project.



Starting Grants: Domains and Panels

For each call there are 27 panels, each covering a sub-section of one of three domains:

- Social sciences and Humanities (SH)
- Life sciences (LS)
- Physical and Engineering Sciences (PE)

Each ERC panel consists of a chairman and 10-16 members. The Panel Chair and the Panel Members are selected by the ERC Scientific Council on the basis of their scientific reputation.

https://erc.europa.eu/funding/starting-grants



Domains and Panels

- Peer reviewers are in charge of assessing and scoring the proposals.
- Those who pass the quality threshold are ranked.
- Depending on the call budget available, a budgetary cut-off applies to the ranking list and only the highest ranked proposals are offered an ERC grant until the call's budget has been used.

https://erc.europa.eu/funding/starting-grants



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step 1: the proposal





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 Monday 14 June 2021 between 20:00 and 21:30 CET: Legal Entity and Bank Account validations tasks will experience issues in the Grant Management Services. The Identity, Bank Account, Contracts & Payments functionalities in the Experts Area of the F&T Portal will be unavailable. 												
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Reporting periods

2 scientific reporting periods
 (mid-time; end-time);

• 4 - 5 financial reporting periods (every 12 - 18 months).



The ERC Project Stable and Chaotic Motions in the Planetary Problem

https://677793stablechaoticplanetm.wordpress.com/

- Hosting Institution: University of Padova
- Duration: 2015 2022 (active)
- Budget: 900,000 €





Personnel costs

- 1 PhD position (3 years)
- 10 post--doc positions (1 year)
- 1 senior researcher position (3 years)





Other costs

- 2 conferences
- 1 school
- seminars, invitations
- open access fees



What do we study





a) Planetary, satellite or b) Sun-Earth-Asteroid systems



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Literature

In the 60-70s of XX century,

V. I. Arnold stated a theorem about the existence of an invariant set having positive measure in phase space made of quasi-periodic motions, for suitably small values of μ, of the eccentricities and the mutual inclinations.
The 'theorem' was completely proved by V.I.Arnold, J. Laskar, P. Robutel, M. Herman, J. Féjoz, L. Chierchia, G.P., up to 2011 (chronological order).

• N.N. Nekhorossev proved that a_i afford variations of order μ^a over exponetially long times, $t \sim \mu^{-1} e^{\mu^{-b}}$ (a, b > 0).



The planetary problem

Hamiltonian of (1+n)-body problem:

$$\begin{split} \mathtt{H}(\mathtt{u}, \mathtt{v}) &= \sum_{\mathtt{i}=0}^{\mathtt{n}} \frac{|\mathtt{u}_{\mathtt{i}}|^2}{2\bar{\mathtt{m}}_{\mathtt{i}}} - \sum_{\mathtt{0} \leq \mathtt{i} < \mathtt{j} \leq \mathtt{n}} \frac{\bar{\mathtt{m}}_{\mathtt{i}} \bar{\mathtt{m}}_{\mathtt{j}}}{|\mathtt{v}_{\mathtt{i}} - \mathtt{v}_{\mathtt{j}}|} \\ \mathtt{u}_{\mathtt{i}} &= (\mathtt{u}_{\mathtt{i}1}, \mathtt{u}_{\mathtt{i}2}, \mathtt{u}_{\mathtt{i}3}) \in \mathtt{R}^3 \qquad \mathtt{v}_{\mathtt{i}} = (\mathtt{v}_{\mathtt{i}1}, \mathtt{v}_{\mathtt{i}2}, \mathtt{v}_{\mathtt{i}3}) \in \mathtt{R}^3 \qquad \mathtt{v}_{\mathtt{i}} \neq \mathtt{v}_{\mathtt{j}} \end{split}$$

In the planetary problem:

$$\bar{\mathbf{m}}_{\mathbf{i}} = \begin{cases} \mathbf{m}_{\mathbf{0}} & \mathbf{i} = \mathbf{0} \\ \mu \mathbf{m}_{\mathbf{i}} & \mathbf{i} = \mathbf{1}, \cdots, \mathbf{n} \end{cases}$$



This allows to write an Hamiltonian governing only the motion of planets:

$$H = \sum_{i=1}^{n} b_i \left(\frac{|y_i|^2}{2} - \frac{1}{|x_i|} \right) + \mu \sum_{1 \le i < j \le n} \left(\frac{1}{m_0} \frac{y_i \cdot y_j}{c_i c_j} - \frac{m_i m_j}{|c_i x_i - c_j x_j|} \right)$$

• For $\mu = 0$, the system is integrable in the sense of Liouville-Arnold and the motion evolves over Keplerian ellipses.

$$\frac{|y_i|^2}{2} - \frac{1}{|x_i|} = -\frac{1}{2a_i}$$
 $a_i \text{= semi--major axis of the ellipse}$

Keplerian ellipses



$$\begin{split} L_i^2 &= \text{semimajor axis}, \qquad l_i = \text{mean nomaly} \\ C_i &= \text{angular momentum}, \quad P_i = \text{perihelion} \;, \quad P_i \perp C_i \;, \quad |P_i| = 1 \end{split}$$

Unperturbed motion and perturbed motions

When $\mu=0$,

- $\ell_i = \ell_i(0) + n_i t$ moves linearly in time (Law of Equal Areas)
- a_i , P_i , C_i = constant;

When $\mu \neq 0$, one expects that

- the motion of a_i, ℓ_i is a bit perturbed;
- P_i, C_i afford variations along secular times (of order μ^{-1}).



Golas

The project has the following main objectives:

a) to understand conditions of complete stability planetary systems;

b) to find examples of planetary systems out of Nekhorossev regime; e.g., exhibiting Arnold instability;

c) to find orbits of planetary systems out of Arnold's theorem regime. E. g., in conditions of resonance.



The aspect of chaos



credits: team members Sara Di Ruzza (U. Padua), Jerome Daquin (U. Namur)