Programme for Research-Development-Innovation for
Space Technology and Advanced Research - STAR
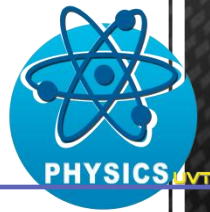
COMPUTATIONAL METHODS IN SCIENTIFIC INVESTIGATION OF SPACE

COMISIS

Dumitru Vulcanov

Romanian Space Week - 2016 , 29 June - 1 July 2016, Bucharest, Romania

COMISIS

- Coordinating organization: West University of Timisoara (CO)
- Project manager: Prof.univ.dr. Dumitru Vulcanov, vulcan@physics.uvt.ro
- Partner organization(s):   University of Craiova (P1)

   "Babes-Bolyai" University of Cluj-Napoca (P2)
- Partner(s) team leader(s):   S.l.dr.ing. Mihai Lungu,

   Conf.univ.dr. Alexandru Marcu

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- Short description of the project:

The project proposes a joint research program having the following main directions:

- Providing an entire computer library devoted to numerical, symbolic computation and algebraic programming methods in space science areas as numerical relativity, nonlinear flow equations and other applications.
- Analytical and numerical models for remote solar and space plasma diagnostics.
- Semi-analytical methods in studying the stability of constrained space flight dynamics.

- Project goal/ objectives:

The main goal of the COMISIS project is to study and develop techniques dedicated to point out:

- effects and new measurements to be done in space for testing the alternative theories and models in astrophysics
- solar and space plasma diagnostics
- semi-analytical studying of the stability of constrained space flight dynamics.

- Human resources involved:
- CO: 4 senior researchers + 1 PhD student
- P1: 6 senior researchers + 1 PhD student
- P2: 3 senior researchers+ 1 PhD student +1 MA student

- Start date of the project / End date of the project: November 2013- November 2016

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- Work plan of the project

WP no.	Work package title	Involved partners	Start month (1 … n-1)	End month (2 … n)
1	Computer library devoted to numerical, symbolic computation and algebraic programing methods in space science	CO, P1,P2	4	34
2	Analytical and numerical models for remote solar and space plasma diagnostics.	CO,P1, P2	6	34
3	Semi-analytical methods in studying the stability of constrained space flight dynamics.	CO, P1,P2	15	34
4	Dissemination, communication, training and education	CO, P1, P2	6	30
5	Management / administration	CO, P1, P2	1	36

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- Implementation status and results of this phase of the project

The main contributions of UVT (CO):

WP 1: COMPUTER LIBRARY DEVOTED TO NUMERICAL, SYMBOLIC COMPUTATION AND ALGEBRAIC PROGRAMING METHODS IN SPACE SCIENCE.

Task 1.3 - Identifying possible effects of different cosmological models on the astrophysical measurements in space.

Task 1.4 – Testing, running and optimizing of different types of routines obtained in view of their packing in one or more dedicated libraries (including User Guide texts).

Results:

A complete package for the study of movement of particles in gravitational fields are introduced using symbolic, numerical and graphical facilities of Maple platform.

On the other side we developed numerical and graphical computer procedures for the study of scattering of fermions and other particles on massive objsects (staars or black -holes)

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■ Implementation status and results of this phase of the project

The main contributions of UVT (CO):

The probability of electron-positron production in dipolar magnetic field on de Sitter spacetime in the case when helicity is conserved or the helicity conservation law is broken is given by:

$$\mathcal{P}_{e^-e^+} = \frac{e^2 \mathcal{M}^2}{16\pi^6(p^2 + p'^2 + 2pp'\cos(\beta - \varphi))^2} \left\{ \frac{\theta(p - p')}{p^2} \left[2\left|f_k\left(\frac{p'}{p}\right)\right|^2 \pm \left(f_k^2\left(\frac{p'}{p}\right) + f_k^{*2}\left(\frac{p'}{p}\right)\right)\right] \right.$$
$$\left. + \frac{\theta(p' - p)}{p'^2}\left[2\left|f_k\left(\frac{p}{p'}\right)\right|^2 \pm \left(f_k^2\left(\frac{p}{p'}\right) + f_k^{*2}\left(\frac{p}{p'}\right)\right)\right]\right\} \left\{ \begin{matrix} (p - p')^2(1 - \cos(\beta - \varphi)) & \text{for } \lambda = -\lambda' \\ (p + p')^2(1 + \cos(\beta - \varphi)) & \text{for } \lambda = \lambda' \end{matrix}\right. .$$

Plot of the probability of electron-positron production in dipolar magnetic field on de Sitter spacetime in terms of the parameter k=(particle mass/expansion factor), for the momenta ratio p/p'=0.001

The case when helicity is conserved is represented by the dotted line and the helicity nonconserving case is represented by the solid line:
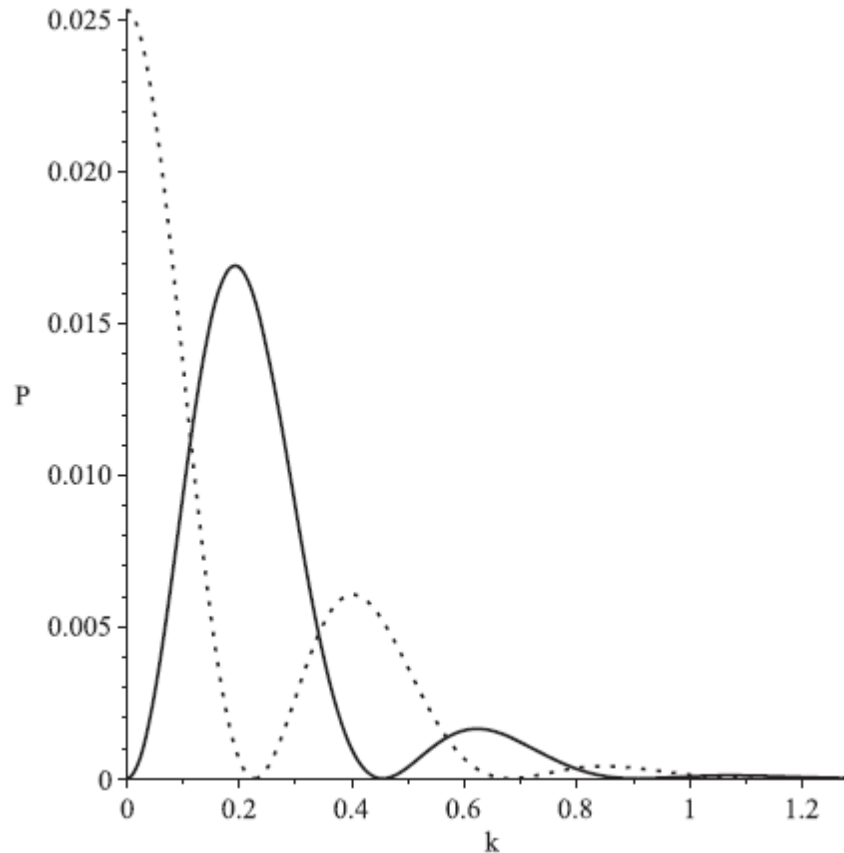
■ Implementation status and results of this phase of the project

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The probability   magnetic field
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$$\mathcal{P}_{e^- e^+} = \frac{}{16\pi} \quad \text{P}$$

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$$\text{for } \lambda = -\lambda'$$
$$\text{for } \lambda = \lambda'$$

Plot of the prob   lar magnetic
field on de Sitter   ticle
mass/expansion

The case when helicity is conserved is represented by the dotted line and
the helicity nonconserving case is represented by the solid line:

COMISIS

- Implementation status and results of this phase of the project

The main contributions of UVT (CO):

We investigate the free falling of particles **along the geodesics described by the Schwartzschild and Reissner-Nordstrom metrics**

Schwartzschild

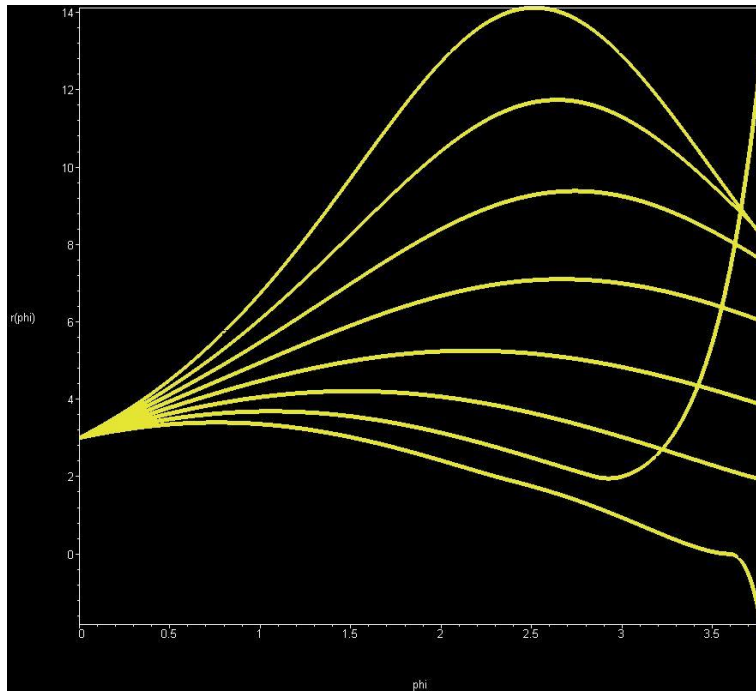$$ds^2 = (1 - \frac{2m}{r})dt^2 - \frac{dr^2}{1 - \frac{2m}{r}} - r^2(d\theta^2 + \sin^2\theta d\varphi^2)$$

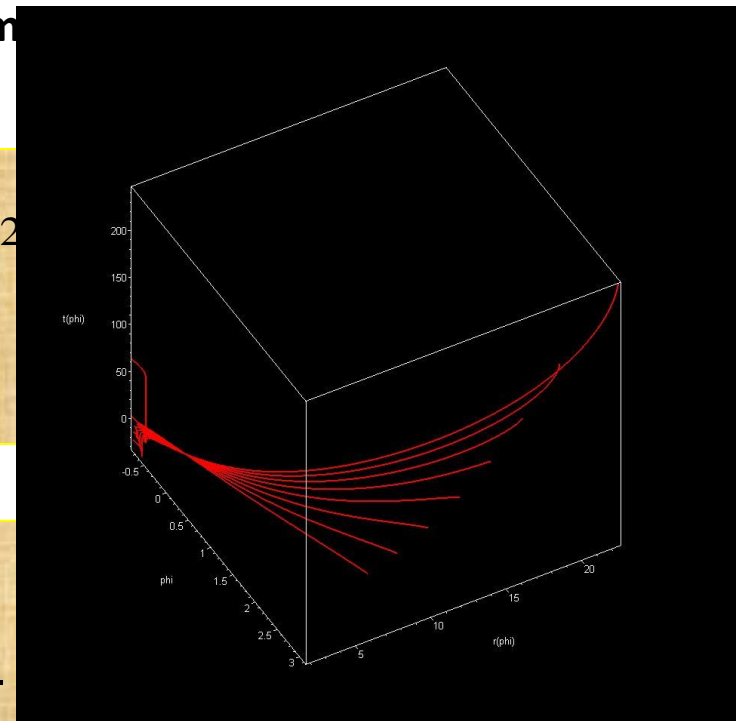$$1 - \frac{2m}{r} - \frac{\lambda r^2}{3} + \frac{e^2}{r^2}$$

Reissner-Nordstrom,

...esults of this phase of the project

...):

...particles **along the geodesics described by**
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$$\frac{r^2}{1 - \frac{2m}{r}} - r^2$$

$$1 - \qquad\qquad r \qquad 3 \qquad r^2$$

Reissner-Nordstrom,

COMISIS

- Implementation status and results of this phase of the project

The main contributions of UVT (CO):

One of the goals of our research is to provide data for certain astrophysical measurements (to be done in space with space telescopes) in order to study the movement of stars or group of stars around the central supermassive blackhole in the center of our galaxy. These data will give informations on the effects of the charge of the blackhole or on the cosmological constant possible to exists

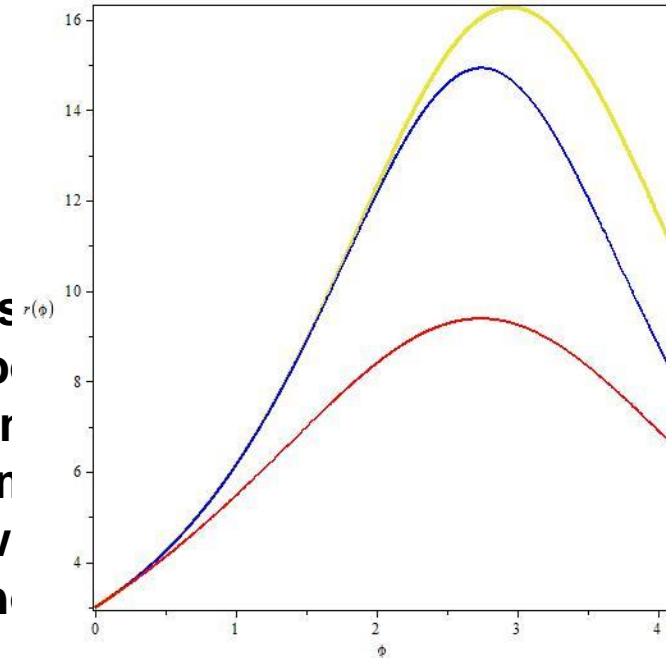**Differences between trajectories at the same initial data in the three cases :**
- **Red line = Schwaetzschild**
- **blue line = Reissner-Nordstrom**
- **Yellow line = Reissner-Nordstrom with cosmological constant**

COMISIS

▪ Implementation status and results of this phase of the project

CO):
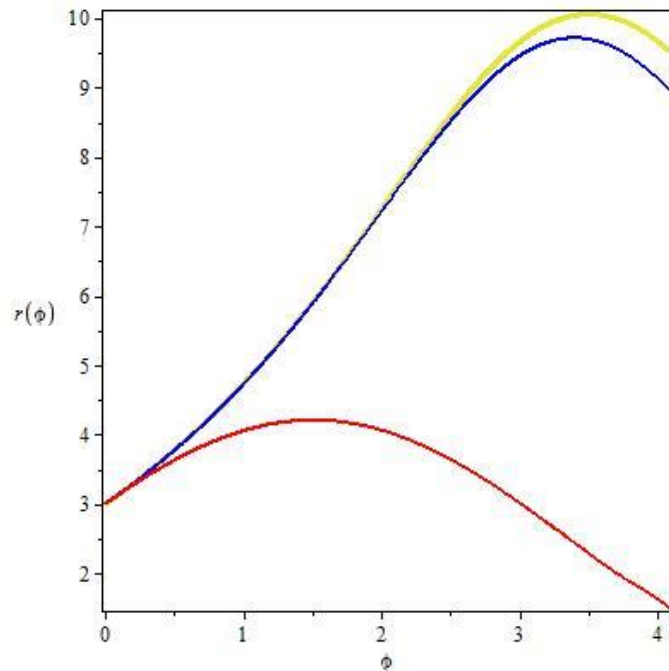
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Differences between trajectories at the same initial data in the three cases :
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- **Yellow line = Reissner-Nordstrom with cosmological constant**

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▪ Implementation status and results of this phase of the project

The main contributions of UVT (CO):

Articles and conference talks :

1. **I.I. Cotaescu, et. al., Int. J. Mod. Phys. B,** Vol. 30, No. 1 (2016) 1550245.
2. **I.I. Cotaescu, et.al., accepted for publication to Int. J. Mod. Phys. B.**
3. **I.I. Cotaescu, talk given at TIM 15-16 Physics Conference, Timisoara (27-28 May, 2016).**
4. **C. Crucean and M-A. Baloi, Fermion production in a magnetic field in a de Sitter universe, Phys. Rev. D 93, 044070 (2016).**
5. **I.I. Cotaescu, C. Crucean, C.A. Sporea, Partial wave analysis of the Dirac fermions scattered from Schwarzschild black holes, EPJC, vol. 76, no. 3 (2016) 102.**
6. **C.A. Sporea, A. Borowiec, Low energy greybody factors for fermions emitted by a Schwarzschild-de Sitter black hole, Int. J. Mod. Phys. D, vol. 25, no.4 (2016) 1650043.**
7. Ciprian A. Sporea, Dumitru N. Vulcanov, "Using MAPLE+GRTensorII in teaching basics of general relativity and cosmology", Romania Reports in Physics ,vol. 68 No. 1, p. 29-40 (2016).
8. D.N. Vulcanov -**Computational methods in the study of the geodesic movement of particles in gravitational fields .talk at Sinaia Spring School of Quantum Hamiltonian Systems, in preparation to be submitted to CPC (2016)**

COMISIS

- Implementation status and results of this phase of the project

The main contributions of UCV (Partner 1):

WP 3: SEMI-ANALYTICAL METHODS IN STUDYING THE STABILITY OF CONSTRAINED SPACE FLIGHT DYNAMICS

Task 3.3: Studies on the motion of objets (including geodesics) orbiting around massive masses (Earth, Sun, other massive stellar objects) and identification of possible effects of alternative gravity theories using PNA and computational new methods (in collaboration with CO).

Task 3.4: Symmetry method and similarity solutions for nonlinear evolutionary equation appearing in space dynamics.

Main problems studied :

- Extension of the semianalytical theory of sattelites of Draper for the stability of space shuttle orbits
- Developpemnt of some specific applications of stability theory for the study of moving in turbulent atmospfere

Some off these investigations were done in collaboration with CS ROMANIA private comoany

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- Implementation status and results of this phase of the project

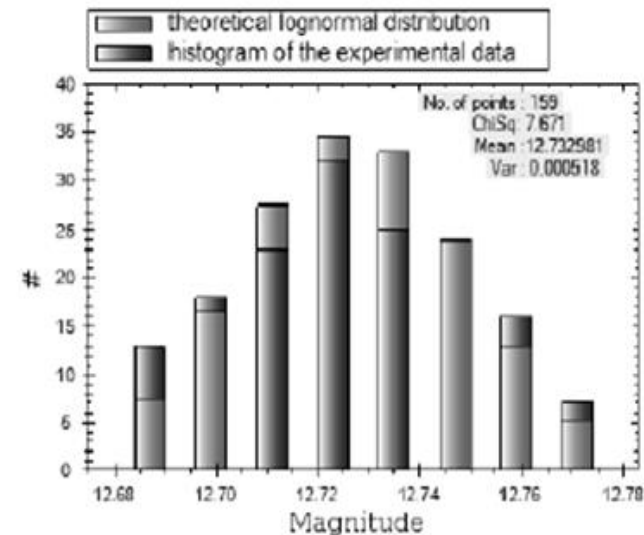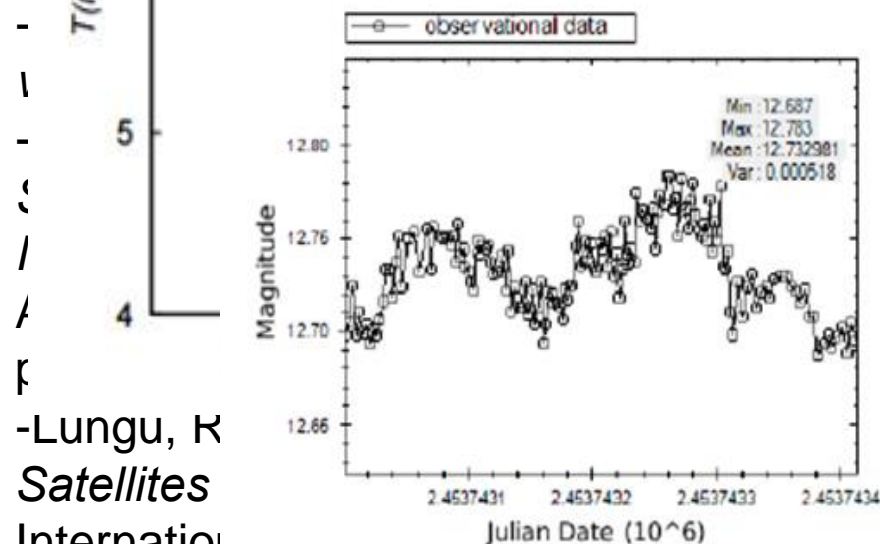The main contributions of UCV (Partner 1):

Articles and talckas at conferences :
-Constantinescu, R., Ionescu, C., Panaintescu, E., Petrisor, I. - *Control and optimization techniques for "jerk" type circuits*: lucrarea a fost prezentata in cadrul Workshopului „Theoretical and computational methods in dynamical systems and fractal geometry", Maribor 7-11.04.2015.
-Cimpoiasu, R. - *On symmetry groups of a 2D nonlinear diffusion equation with source. Pramana, 4(84), 543-553* (2015).
-Lungu, R., Lungu, M., Ioan, M. - *Determination and Control of the Satellites' Attitude by using a Pyramidal Configuration of Four Control Moment Gyros,* 12th International Conference on Informatics in Control, Automation and Robotics (ICINCO 2015), Colmar, Franta, 21-23 Iulie 2015, pag. 448-456.
-Lungu, R., Lungu, M., Ioan, M. - *Nonlinear Automatic Control of the Satellites by using the Quaternion and the Angular Velocities' Vectors*. 3rd International Workshop on Numerical Modelling in Aerospace Sciences (NMAS 2015), Bucureşti, 6-7 Mai 2015.

COMISIS

▪ Implementation status and results of this phase of the project
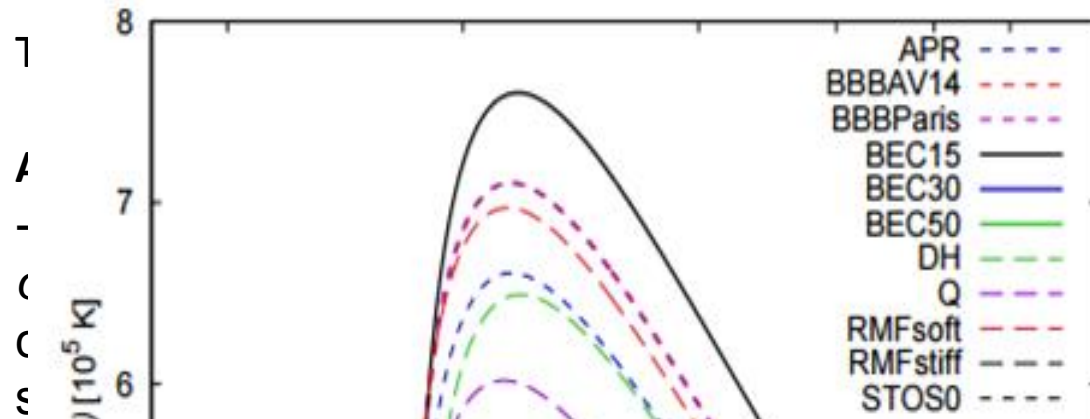
...isor, I. - *Control and*
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-Lungu, R...
Satellites
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(NMAS 2015), Bucureşti, 6-7 Mai 2015.

# COMISIS

The main contributions of UBB (Partner 2):

WP 2: ANALYTICAL AND NUMERICAL MODELS FOR REMOTE SOLAR AND SPACE PLASMA DIAGNOSTICS.

Published articles :

-T. Harko, P. Liang, S.-D. Liang, G. Mocanu, "*Testing the Bose-Einstein Condensate dark matter model at galactic cluster scale*" Journal of Cosmology and Astroparticle Physics, acceptat 2015, iopscience.iop.org/14757516/page/Forthcoming%20articles

-G. Mocanu, "*C0-semigroups generated by second order differential operators*" Annales Polonici Mathematici, 2015 acceptat.

-B. Danila, T. Harko, G. Mocanu, „*Self Organized Criticality in a two dimensional Cellular Automaton model of a magnetic flux tube with background flow",* Monthly Notices of the Royal Academy, 453 (3): 2982-2991 (2015) .

-T. Harko, G. Mocanu, N. Stroia, „*Self Organized Criticality in an one dimensional magnetized grid. Application to GRB X-ray afterglows",* Astrophysics and Space Science, 357 (2015), 1-9.

-B. Dănila, T. Harko, Z. Kovacs, „*Thin Accretion Disks around cold Bose-Einstein Condensate stars",* European Physical Journal C, (2015) 75 (5) 203.

-B. Dănilă, A. Marcu, G. Mocanu, "*New statistical results on the optical IDV data of BL Lac S5 0716+714",* Research in Astronomy and Astrophysics, 15 (2015), No. 3, 327-332.

-G. Mocanu, I. Raşa, "*C0-semigroups associated with Markov operators",* Mediterranean Journal of Mathematics (2015), DOI 10.1007/s00009-014-0497-8.

Magyar, N.; Van Doorsselaere, T.; Marcu, A., "*Numerical simulations of transverse oscillations in radiatively cooling coronal loops",* Astronomy & Astrophysics, Volume 582, id.A117, 8 pp. DOI10.1051/0004-6361/201526287.

The main contributions of UBB (Partner 2):

WP 2: ANALYTICAL AND NUMERICAL MODELS FOR REMOTE SOLAR AND SPACE PLASMA DIAGNOSTICS.
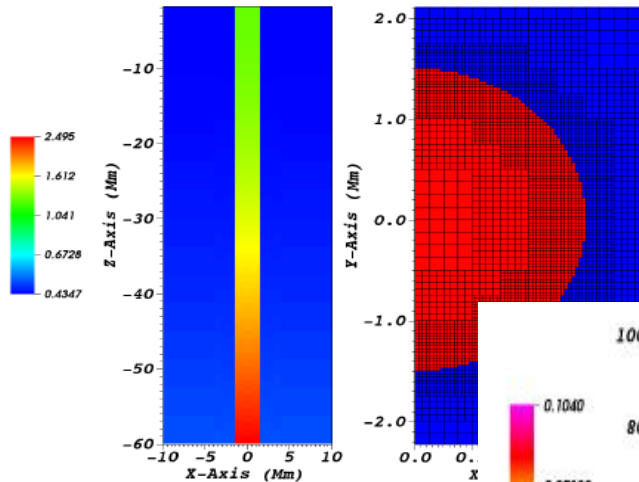
anu, "*Testing the Bose-Einstein Condensate dark
ournal of Cosmology and Astroparticle Physics,
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" *by second order differential operators*" Annales

357 (2015), 1-9.
-B. Dănila, T. Harko, Z.
Condensate stars", Eu
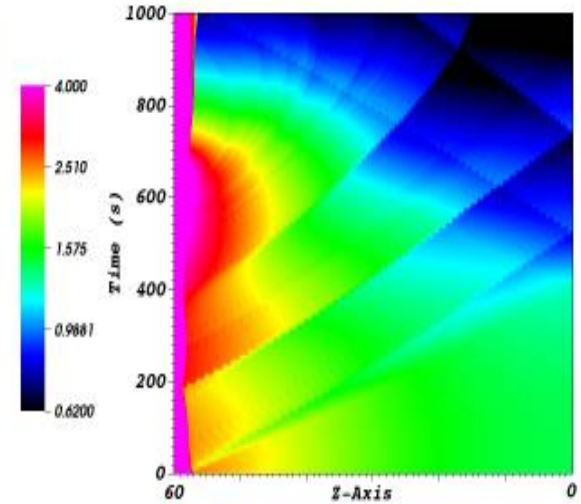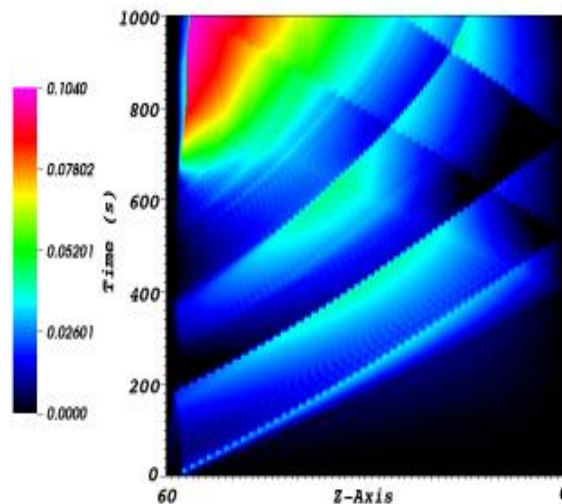-B. Dănilă, A. Marcu, G
S5 0716+714", Resear
-G. Mocanu, I. Raşa, "
Journal of Mathematics
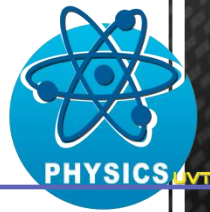Magyar, N.; Van Doors
oscillations in radiative
id.A117, 8 pp. DOI10.1051/0004-6361/201526287.

COMISIS

- Project's contribution to the goal of the STAR Programme:
- Context and contribution to ESA Programmes:

Within the general ESA and STAR objectives, the COMISIS Project has the following general aims:

- Producing high-level scientific results and output increasing the international recognition and relevance of the Romanian science.

- Improving the capacity of the partner institutions to built research and educational projects in space science and technology.

- Development of software technologies as support of experiments and measurements in space missions.

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- Dissemination activities:

Various dissemination activities of COMISIS Project were organized within scientific and public events as:

- TIM' 15-16 International Conferences (organized by CO)
- "Joint Meeting in Quantum Field Theory and Dynamical Systems" (organized by P1).
- Open Days of West University of Timisoara (April 2016)

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- Conclusions:

1) The tasks and the objectives assumed are in the right schedule.

2) The results of this stage of the project are included in 9 ISI articles published or to be published.

3) The teams provide a healthy collaboration inside the consortium.

The main conclusion is that there are good opportunities to bring the tasks and objectives of the project to a succesfull end.