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Integrated Medium for Planetary Exploration (IMPEx): a new EU FP7-SPACE project

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Abstract

A new FP7-SPACE project Integrated Medium for Planetary Exploration (IMPEx) has been started in June 2011. It will create an interactive framework for exploitation of space missions' data. Data analysis and visualization will be based on the advanced computational models of the planetary environments. The project infrastructure will enable joint interconnected operation of spacecraft data bases and the scientific modelling tools, serving to better understanding of related physical phenomena.

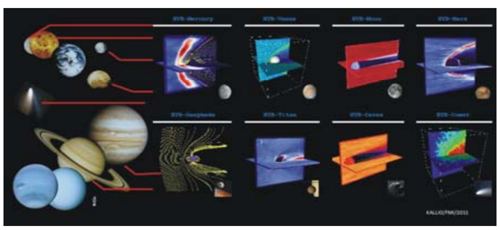

Figure 1 3D HYB Model environment of planetary objects (Mercury, Earth, Jupiter, Saturn and etc.).

1. Introduction: Project motivation

Acquisition of experimental data by space mission measurements and interpretation of these data on the basis of developed theoretical concepts and models are two major mutually connected aspects of the modern space research. Numerical modelling, as a way to reproduce complex natural phenomena and to understand them by computational simulation, plays here an important role. By this, the observational data on one hand are considered as a verification test for validity checking of existing models, on another hand they appear a driver for further improvement of existing models and development of new ones. At the same time, the scientific potentials of the combined use of experimental data and numerical models in their mutually complimentary way are still not realized. Creation of an integrated IT framework where numerical models are interconnected to the experimental data and used in combination with the last for simulation of space phenomena and interpretation of spacecraft measurements is an actual task.

2. Main objectives of the project

IMPEx is aimed at creation of an interactive computational framework where data from planetary missions will be interconnected with numerical models providing a possibility 1) to organize data in a more compact and more clear form; 2) to test models versus experimental data and to perform further improvement of models; 3) to fill gaps in the measurements by appropriate modelling runs; 4) to simulate planetary phenomena and interpret space missions measurements; 5) to perform preparation of specific mission operations and to solve various technological tasks, including preparation of new missions. In view of the strong European engagement into past, present and forthcoming space missions to Mercury (Bepi Colombo), Venus (VenusExpress), Earth (Cluster, Themis), Mars (MarsExpress), Jupiter and Ganymede (Galileo, JGO), Saturn and Titan (Cassini), Comet 67P (Rosetta), the project IMPEx will have its primary focus at plasma and magnetic environments of these missions targets. The target audience of IMPEx users comprises the planetary science community including data analysts, basic researchers, as well as mission and instrument designers.

3. Work programme, methodology

The 'modeling sector' of IMPEx is formed of three well established numerical codes and their related computational infrastructures which will provide the scientific community with a set of computational models of the project target planetary objects. These codes are: 1) 3D hybrid modeling platform HYB for the study of planetary plasma environments (see Fig.1), hosted at FMI; 2) an alternative 3D hybrid modeling platform, hosted at LATMOS; 3) MHD modelling platform for 3D terrestrial magnetosphere, hosted at FMI; and 4) the global 3D Paraboloid Magnetospheric Model for simulation of magnetospheres of different Solar System objects, hosted at SINP. The environment, where the modelling results will be linked to the corresponding experimental data from space missions is provided by AMDA (Automated Multi-Dataset Analysis, http://cdpp-amda.cesr.fr/). The AMDA-based platform will provide cross-linked visualization and operation of experimental and numerical modelling data. It will be supplied with a multi-mission 3D visualization tool "3DView Multi-mission" and "CLWeb" software which enable 3D visualization of position/orientation of spacecraft, and computation of various physical characteristics (spectra, distribution functions, etc.).

In practice, IMPEx is going to provide an external user with an access to an extended set of space missions' data and powerful, world leading computing models, equipped with advanced visualization tools. It will enable 1) to select, download, visualize and analyze data from the modelling runs, 2) to superimpose them with the measurements performed by spacecraft, and 3) to run specific modeling tools on request. Besides of that, development of a set of scientific tools and functionalities for the support of preparation and operation of space planetary missions is envisaged within IMPEx. This will include a possibility to fly virtual spacecraft in 3D model environment and to visualize expected plasma observations from the simulation databases.

4. Expected scientific and technological results

In course of its implementation IMPEx will provide the international planetary science community with a new research infrastructure which will enhance the efficiency of space mission data exploitation on one hand, and serve as a tool for better preparation of mission operations and solving various technological issues, including preparation of new missions, on the other hand. It will also provide an environment for testing and further improvement of existing models versus experimental data. Via its infrastructure, IMPEx will bring the data and models outside of the mission teams and specialized computational modelling groups making them accessible and useful for a broad planetary science community and promoting in this way the contribution of space assets to scientific/technological knowledge. The project IMPEx will create for the first time a working prototype of an infrastructure which bridges the gap between spacecraft data bases and the scientific modelling tools enabling their joint interconnected operation. It will use models for organization of data in data bases, resulting in a more compact and more clear presentation of the main results of the space missions. By this, the global models of the Solar system objects operated in IMPEx will provide the whole complex of self-consistently simulated physical parameters which are (or can be) at the same time measured by different space-based instruments. This will open for the first time an opportunity to "connect", with the help of models, different observational data sets and to build a global view of the complex planetary phenomena. The unique feature of the IMPEx project is that it will result in a generic data-model platform for connection of various data archives and modeling support tools.

5. Foresights in future

It is foreseen that successful implementation of IMPEx research infrastructure and the universality of its architecture, as well as the analysis/visualization tools and standards, will stimulate other modelling groups in Europe to propose their services for the integration in IMPEx. In general, IMPEx will ensure a longer and more efficient use of space mission data in the worldwide research community, also far beyond a particular mission duration timeframe. This will naturally increase added value of the European space mission investments. Development of IMPEx beyond FP7 supposes extension of the scope of planetary objects, used models, and observational data.

6. Major facts of IMPEx

Starting date: June 2011
Duration: 48 months
Key roles:
Coordinator - M. Khodachenko (IWF-ÖAW)
Deputy-Coordinator - E. Kallio (FMI)
Project Scientist - V. Génot (CNRS/IRAP)
Project manager - T. Al-Ubaidi (IWF-ÖAW)
WP Leaders - M. Gangloff (CNRS/IRAP); I. Alexeev (SINP); W.Schmidt (FMI);