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Sciences pour les Exoplanètes et les Systèmes Planétaires

Françoise Roques, Christian Balança, Yves Bénilan, Jean-Mathias Grießmeier,
Emmanuel Marcq, T. Navarro, Stefan Renner, Jean Schneider, C. Schott

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SCIENCES POUR LES EXOPLAN TES ET LES SYST MES PLAN TAIRES

F. Roques¹, C. Balan a², Y. B nilan³, J.M. Griessmeier⁴, E. Marcq⁵, T. Navarro⁶, S. Renner⁷, J. Schneider⁸ and C. Schott¹

Abstract. The websites **Sciences pour les Exoplan tes et les Syst mes Plan taires** È (SESP) and **Exoplan tes** present planetary and exoplanetary sciences with courses, interactive tools, and a didactic catalogue connected to the Encyclopedia exoplanet.eu. These websites have been created in the context of the LabEx ESEP (Exploration Spatiale des Environnements Plan taires) and they are directed towards undergraduate level. They can be used as support for face-to-face courses and self-training. The websites will be translated and will be used to create e-learning degree courses.

SESP : <http://sesp.esep.pro/fr/index.html>

EXOPLANETES : <http://exoplanetes.esep.pro/>

Keywords: exoplanets, planetary systems, website, e-learning

1 Introduction

The aim of this project is to provide free access to high quality scientific information and multimedia tools developed for learning planetary and exoplanetary sciences. Both websites **SESP** and **Les exoplan tes** are created under Creative Common license (BY NC SA) : *You are free to - Share (copy and redistribute the material in any medium or format) - Adapt (remix, transform, and build upon the material)*. A more precise description of the License is here : <https://creativecommons.org/share-your-work/licensing-types-examples/>. The courses are for undergraduate level (equivalent to L1 to L3 in the European LMD system) and the Exoplan tes website is for general public. They can be used for face-to-face or remote learning scientific degrees, or training courses aimed at high-school teachers, scientific mediators or journalists.

2 A digital book on (exo)planetary sciences

The digital book **Sciences pour les exoplan tes et les syst mes plan taires**, , presents the current knowledge about planetary systems through the sciences that support this knowledge: maths, physics, chemistry... The chapters are standalone modules written by researchers and professors who are specialists in the field. Each of them corresponds to roughly 10 hours of student's work.

They share a common structure: - **Discover**: description of the astrophysical object, with none or few equations. - **Understand**: the sciences necessary for the study of the object. **Self-test**: self-assessment exercises, to check that the chapters are understood and known. - **Mini-project**: a data analysis project with scientific data about solar system planets or exoplanets.

The authors followed these guidelines to create the chapters listed below. The titles in bold are chapters accessible from Autumn 2016. Several interactive tools have been created for these modules (Fig. 1).

¹ LESIA, Paris Observatory, France

² LERMA, Paris Observatory, France

³ LISA, Univ. Paris-Est, France

⁴ LPC2E, Univ. Orl ans, France

⁵ LATMOS, Univ. Versailles, France

⁶ LMD, IPSL, France

⁷ IMCCE, Paris Observatory, France

⁸ LUTH, Paris Observatory, France

<p>Planètes et exoplanètes: Histoire et définitions</p> <p>Exoplanètes : Statistique et probabilités Dynamique des systèmes planétaires Structure interne Structure thermique des atmosphères planétaires Dynamique atmosphérique Rayonnement électromagnétique : Flux et spectre Flux U.V. Plasmas planétaires: mesures in-situ Imagerie directe d'exoplanètes</p> <p>Détection de transits d'exoplanètes Habitabilité.</p>	<p>Formation et évolution des systèmes planétaires Les orbites planétaires Surfaces planétaires Composition des atmosphères planétaires Modèle de circulation générale des atmosphères Petits corps du système solaire Polarisation</p> <p>Flux radio Relations étoile-planètes Méthodes de détection d'exoplanètes par vitesse radiale et astrométrie Exobiologie</p>
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3 An educational website on exoplanets

The website **Exoplanètes**, is based upon a catalogue of exoplanets which is a simplified mirror of the catalogue of the Encyclopedia <http://exoplanet.eu>. It is less complete than the research catalogue, however it is up to date with the latest discovered exoplanets. Whenever possible, the catalogue computes an equilibrium temperature (assuming a 0.3 albedo) and the planet density. In addition to the catalogue, the website contains visualization tools to work on the data, histogram and 4-parameter diagram (Fig. 2). Commented diagrams show how these statistical tools help to explore the properties of the exoplanetary systems, the outstanding issues. The site contains a table of exoplanet families, an exoplanet counter, 2D and 3D sky maps, along with small chapters answering questions about exoplanet definitions, discovery methods, habitability. A 3D simulator shows the structure of all the exoplanetary systems, compares it with the solar system and displays an estimation of the habitable zone, with all the precautions on the use of this term.

4 Future: E-learning projects

Further chapters are still in progress in the digital book. Projects are underway for diploma distance training on planetary sciences and exoplanets, taking advantage of the 10 years e-learning experience of the Paris Observatory. These training will be given at University of Versailles and at the Paris Observatory : <http://ufe.obspm.fr/Formations-en-ligne/ASTROPHYSIQUE-SUR-MESURE/Parcours.html>. Moreover, the exoplanets website will be translated into English, Brazilian, Italian, Spanish, Chinese.

5 The team

5.1 The editorial committee

Françoise Roques (LESIA), Stefan Renner (IMCCE), Thomas Navarro (LMD), Jean-Mathias Griessmeier (LPC2E), Christian Balança (LERMA), Emmanuel Marcq (LATMOS), Yves Bénilan (LISA) et Jean Schneider (LUTH).

5.2 The authors and reviewers

Alain Doressoundiram (LESIA), Christian Balança (LERMA), Jean-Loup Baudino (LESIA), Yves Benilan (LISA), Benjamin Charnay (LESIA), Jean-Yves Chaufray (LATMOS), Valérie Ciarletti (LATMOS), Thierry Dudok de Wit (LPC2E), Stéphane Erard (LESIA), Sylvain Fouquet (GEPI), François Forget (LMD), Thierry Fouchet (LESIA), Nicolas Fray (LISA), Jean-Mathias Griessmeier (LPC2E), Anaelle Halle (LESIA), Nathan Hara (IMCCE), Jacques Laskar (IMCCE), Sébastien Lebonnois (LMD), Emmanuel Lellouch (LESIA), Alice Le Gall (LATMOS), Lucie Maquet (IMCCE), Emmanuel Marcq (LATMOS), Sophie Masson (LESIA), Stéphane Mazevet (LUTH), Ronan Modolo (LATMOS), Yael Nazé (U. Liege), Thomas Navarro (LMD), Filippo Pantellini (LESIA), Didier Pelat (LUTH), Arianna Piccialli (LESIA), François Raulin (MNHN), Françoise Roques

(LESIA), Loic Rossi (LATMOS), Patricia Schippers (LESIA), Jean Schneider (LUTH), Bruno Sicardy (LESIA), Philippe Thébault (LESIA) et Martin Turbet (LMD).

5.3 *The technical team*

Project manager : Cédric Schott - Groupe Informatique du LESIA : Florence Henry, Emmanuel Grolleau, Julien Brulé - Graphics : Sylvain Cnudde - Software maintenance : Soufiane Ayadi, Damien Guillaume - Communication : Séverine Raimond.

6 Conclusions

These websites are free of use, in face-to-face or distance courses. Any experience feedback on the use of these resources are welcome.

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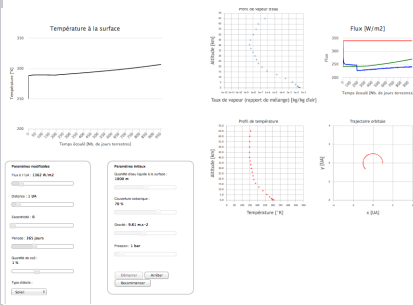


Fig. 1. One page of the digital book **Sciences pour les Exoplanètes et les Systèmes Planétaires** and examples of applets : occultation by Venus - interactive GCM - crater formation.

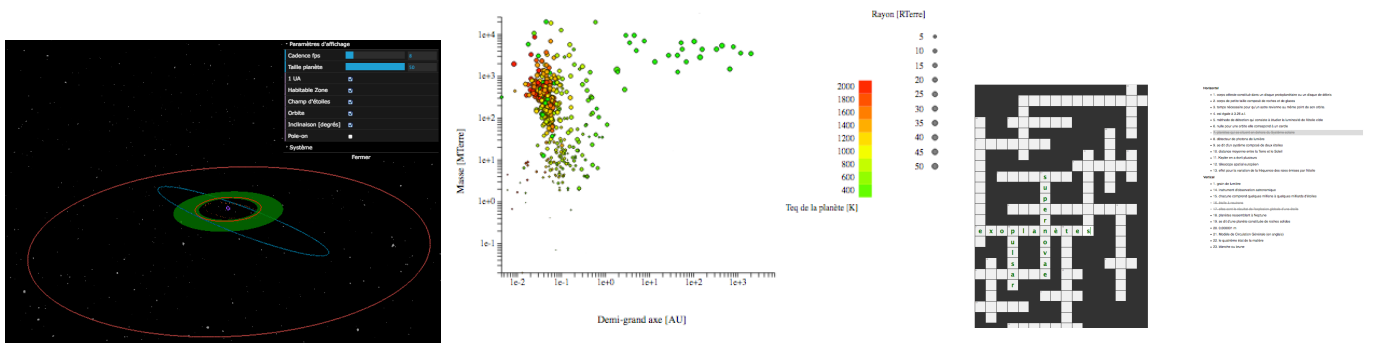


Fig. 2. Pages of the website Exoplanètes