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Gaia-GOSA: An interactive service for coordination of asteroid observation campaigns

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Abstract

We present the Gaia-Groundbased Observational Service for Asteroids (GOSA). Gaia-GOSA is an interactive tool which supports observers in planning photometric observations of asteroids. Each user is able to personalise the observation plan taking into account the equipment used and the observation site. The list of targets has been previously selected among the most relevant and scientifically remarkable objects, while the prediction of the transits in the Gaia's field of view have been calculated at the Observatoire de la Côte d'Azur. The data collected by the GOSA community will be exploited to enhance the reliability of the Gaia's Solar system science. The service is publicly available at www.gaiagosa.eu.

1. Introduction

To help amateur observers playing an important role in professional astronomy and provide valuable observation record that will be used when analysing the Solar System Objects (SSO) Gaia release, we have created a WWW service called Gaia-Groundbased Observation Service for Asteroids (Gaia-GOSA). The service is publicly available at www.gaiagosa.eu. Any user of the service is able to easily create an account, acquire the list of observation targets (in accordance with the Gaia observations) adapted for the specific user's instrument and observation site. The users are also able to upload the gathered observation data to the server as the material for further research. These data will help the astronomers disentangling problematic inversion cases of the Gaia data, confirm suspected binaries or determine and improve asteroids' synodic period measurements. The service is available for the general public, but the registered users are able to enjoy a more personalised service experience: personalised observation planner, social networking with other observers, take part of the users ranking based on the scientific value of uploaded data, etc.

2. Transits of Solar system objects in 2015

The Gaia-GOSA aims to release to the general public part of a highly specialized product generated within the Gaia-DPAC Solar system group. In order to make this product useful to the general community it should accomplish the following points:

1. It shall be understandable without any previous knowledge of the Gaia mission
2. It cannot contain specialized information or too many data
3. It shall provide clear instructions on how to use the product

The prediction of transits of Solar system objects will be calculated approximately once per year at the Observatoire de la Côte d'Azur (OCA), due to the impossibility of predicting some of the input parameters for a longer period. These predictions were generated by F. Mignard from the OCA using the transit predictor developed within the DPAC-CU4/SSO [1]. For each release, we aim to select the most interesting targets under a scientific criteria and publish their predictions at the GOSA. In return, we expect gathering observations from the users, which will be analysed at the Astronomical Observatory of the Adam Mickiewicz University (AO AMU). The results obtained will be published at the GOSA site as well as in specialized journals, while feedback about the observation quality will be sent to the users. The full expected flowchart of the data processing design is shown in Fig. 1.

3. Combining Gaia observations with ground-based lightcurves

Combining Gaia observations of asteroids with ground-based lightcurves becomes straightforward when both observations are taken simultaneously. In

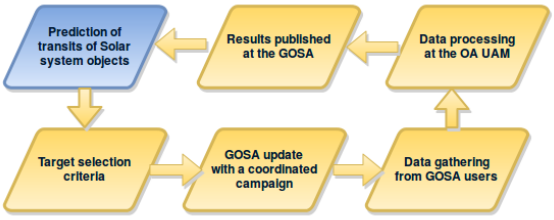

Figure 1: Flowchart of the GOSA data processing design.

contrast, if the lightcurve obtained from the ground does not include the epoch of observation by Gaia, there may be problems to link the Gaia observation to the rotational phase, and to calibrate the magnitudes of the ground-based data, especially in cases when the lightcurve is complex and the period resulting from the lightcurve is uncertain. The GOSA is publishing the Gaia observation sequence for selected Solar system objects, allowing the observers to obtain a lightcurve of a certain asteroid at the same time as Gaia is collecting a very precise photometric measurement. Later on, it will be possible to calibrate the ground-based observation (even if it is relative photometry) with the Gaia absolute magnitude, and proceed with the inversion process normally. Formally, the only difference between data sources will appear during the preparation of the input file containing the photometric error associated with each observational instrument and the position vectors of the observer.

4. Target selection criteria

Based on the results obtained in Santana-Ros et al. 2015 [2], we defined the first target selection criteria: additional ground-based observations are sought for asteroids with low pole latitudes, suspected nearly spherical shape and with less than 50 Gaia transits. However, we are not able to predict the transits of Solar system objects until the end of the mission, as the predictions require for regular corrections due to unpredictable parameters, such as micrometeorite impacts on the spacecraft surface. Thus, for such group of objects, it will be necessary to perform data mining at the end of the Gaia mission in order to enhance their inversion results. In addition to these results, we recommend to include as GOSA targets asteroids which might be scientifically interesting for the Solar system science community. Such objects include:

- Known or suspected binary asteroids
- Suspected fast rotators (period shorter than 1 hour) for which Gaia could have problems for the period determination
- Interesting categories, including strange spectral types, asteroid families, slow rotators, etc.

Based on these considerations, the AO AMU has prepared a list of interesting targets, which are included in GOSA. However, we consider this list to be dynamical, in the sense that more targets can (or shall) be included. Some examples might be: newly discovered NEOs, targets of opportunity for other observational techniques (radar echo, adaptive optics, stellar occultation), objects for which a new relevant discovery has been done. For this reason, we allow GOSA users to submit requests to add objects to the target list if they can show them to be scientifically meaningful.

5. Summary and Conclusions

We have created an interactive tool which allows observers from all around the world to plan their observations with a concrete scientific goal (enhance the Gaia Solar system science), coordinate with other observers in observational campaigns, and feel the excitement of being part of a real space mission such as Gaia. We encourage all the observers to register for free at the GOSA site (www.gaiagosa.eu) and spread the word to other astronomy fans.

Acknowledgements

We thank F. Mignard and P. Tanga (OCA, Nice) for putting at our disposal the transit predictions of Solar system objects. The web service has been developed by OA AMU in collaboration with ITTI Sp. z o.o. while the data processing is provided by OA AMU. The service has been funded under the ESA Contract No. 400011266014/NL/CBi: "Gaia-GOSA: An interactive service for asteroid follow-up observations.".

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Vigie-Ciel, a collaborative project to study fireballs and organise meteorite recoveries

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Abstract

Research on fireballs and meteorites has always been of interest to the public, due to the beauty of shooting stars in the night sky and to the extraterrestrial origin of meteorites. A fireball observation network called FRIPON [1] (Colas et al, 2015) is currently being setup, funded by ANR (Agence Nationale pour la Recherche). It will cover France with 100 cameras and is expected to be operational for the end of 2015. FRIPON will detect fireballs and hence allow us to define meteorite strewn fields within 24h, so that meteorite searches can be launched very early on. Because of the need to search all over France, including in private land, it is important that the general public be aware of our project and be willing to help or participate. Indeed, as the main goal of FRIPON is to recover fresh meteorites (within a few days), our aim is to be able to organize a search with at least 50 persons to scan an area of a few km^2 within a week. Help from the public would hence be most helpful but it is also important to have an operational and trained research team. This project thus appears as a unique occasion to involve the public in a scientific project while promoting informal scientific education. This prompted us to set up Vigie-Ciel, a citizen science network centered on meteorite recovery. FRIPON is an open network based on open-source software, it will accept citizen-run cameras. In addition to fireballs, it will allow scientists and Vigie-Ciel participants to study anything that can be observed by all-sky cameras: bird migrations, bats, clouds, lightning, etc. The data will be freely available to all.

1. Collaborative sciences in France

1.1 Natural sciences

The MNHN (Muséum National d'Histoire Naturelle) has had experience in citizen science networks in natural history for close to 30 years. It runs a series of programs on varied topics (birds, bees, bats, plants in towns…) built over time by a number of researchers with the help of associations involved in nature study and protection. The development of new communication technologies fundamentally changed the number of participants and the amount of data to be processed. Moreover, these programs having all been built small and independently, they are not designed to operate together smoothly and basically each have their own website. As a result, someone wanting to participate in several topics will have to manage several memberships, several philosophies for data base management. MNHN hence decided to integrate the running of all these programs in a global project called "65 Millions d'Observateurs" (shortened to 65MO and meaning 65 million observers, as France has 65 millions inhabitants!)

1.2 Astronomy

Astronomy is well known to be the oldest science, and therefore the oldest collaborative science as a professional astronomer is quite a "new" concept (only a few hundred years) compared to astronomical history (a few thousand years). As for natural science, the Internet and the new technologies have changed the context. First, all the information is now "on-line" rather than restricted to a few professionals. Secondly, efficient computers and electronic receptors are now affordable for amateurs. It is amazing to think that the groundbreaking work on the expansion of the universe done by Hubble in the fifties with the biggest telescope of the time can now be made with an amateur size telescope! More important is the fact that the sky is huge and that one telescope, even the biggest one, can only observe one

object at a time. This is particularly obvious for asteroid studies where we actually know more than 700 000 objects! As for natural sciences, many programs were developed in France over the years, by SAF (Société Astronomique de France), AFA (Association Francaise d'Astronomie), Planète Sciences, AUDE (Association des Utilisateurs de Détetecteurs Electroniques) etc.

2. 65 Millions Observers (65MO)

To build 65MO, MNHN obtained a grant from a general education and outreach program of ANRU (Agence Nationale de Rénovation Urbaine). 65MO is divided into four sub-programs: Vigie-Nature (the main program on biodiversity and climate change), Vigie-Mer (everything concerning sea and seashore), Vigie-Ciel (fireballs, meteorite searches and crater spotting) and finally Vigie-Nature-Ecole (a program concerning all the topics together, including Vigie-Ciel, but dedicated to students of all levels to teach about sciences and scientific protocols).

3. Vigie-Ciel

The prime object of Vigie-Ciel is to exploit data from the FRIPON network that will be fully operational by the end of 2015. Participation could involve:

- use of the free data produced by the network to study phenomena other than fireballs seen by the cameras: for example cloud cover, bats, bird migrations, lightning, etc.
- direct participation in the network by acquisition of a FRIPON compatible camera,
- development of software based on FreeTure open-source platform,
- participating in the network with images made with digital cameras or visual witnesses obtained and/or sent with smartphones,
- participating in meteorite search campaigns,
- online search for unknown impact structures in aerial photographs of the Earth's surface,
- attendance at educational programs (general public or students; conferences, exhibits, workshops…)

Participants will benefit at a number of levels, one of which is simply the involvement in a scientific quest, obtaining a better understanding of the scientific results obtained by the program and being, in some cases, associated by name with declarations of new meteorites and new craters and other scientific publications. Another benefit will be belonging to a community with a large variety of participants, including scientists, and participating in a project with field work and other informal contacts.

Vigie-Ciel will have a website expected to be fully operational by the spring of 2017. Like FRIPON, the program is structured around regional poles in order to be in close contact with the public all over France to obtain a good knowledge of local conditions and to be able to form search teams that can be active within 48h in the case of a meteorite fall. The centers mainly rely on planetariums, scientific museums and other outreach structures that are connected to the FRIPON network through the scientific centers constituted by local/regional scientific laboratories.

Another goal of Vigie-Ciel is to involve any scientific domain connected to astronomy (from our solar system to the whole universe) and to earth sciences. A good example is Rochechouart (the only known meteorite impact crater in France) where the public will be able to see in the same museum both impact breccias and fireball online detections. Another example is the ability to search for unknown impact structures in aerial photographs of the Earth in an online program similar to Galaxy Zoo.

4. Conclusion

Vigie-Ciel is designed to let the public participate in a true research quest on the universe and reconnect with science using their natural attraction to fireballs and meteorites. It will be based on new information technology but also on direct contacts with the scientists using pedagogic tools that will be specifically designed to show how to recognize a meteorite, to observe radio meteors, etc.

5 Acknowledgements

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Sciences pour les Exoplanètes et les Systèmes Planétaires: websites and e-learning

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Abstract

The websites « *Sciences pour les Exoplanètes et les Systèmes Planétaires* » (SESP) and « *Exoplanètes* » have been created in the context of the LabEx ESEP (*Laboratoire d'excellence Exploration Spatiale des Environnements Planétaires*) [1]. They present planetary and exoplanetary sciences with courses, interactive tools, and a didactic catalogue connected to the Encyclopedia http://exoplanet.eu [2]. These resources are directed towards undergraduate level. They will be used as support for face-to-face courses and self-training. In the future, we will translate some contents into English and create e-learning degree courses.

1. Introduction

The aim of this project is to provide free access to high quality scientific information and multimedia tools for learning planetary and exoplanetary sciences. Both websites *SESP* and *Les exoplanètes* are created under Creative Common 5 license, for undergraduate level (equivalent to L1 to L3 in the European LMD system). They can be used for face-to-face or distant learning scientific degrees, or training coursed aimed at high-school teachers, science guides or journalists.

2. SESP

The website *SESP* presents the current knowledge about planetary systems through the sciences that support this knowledge: maths, physics, chemistry… The chapters are autonomous modules written by researchers and professors 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 no or few equations. - **Understand**: the sciences necessary for the study of the object. **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.

Figure 1: home page of the site *SESP [3]*

23 authors followed these guidelines to create the modules listed below. The website will open in October 2015 with those 23 modules. 28 modules are expected for October 2016.

1-Histoire et définitions des (exo)planètes – 2-Origine et évolution des systèmes planétaires – 3-Statistique sur les exoplanètes – 4-Structure interne des (exo)planètes – 5-Surfaces planétaires – 6-Structure thermique des atmosphères planétaires – 7-Dynamique atmosphérique – 8-Modèle de circulation globale des atmosphères – 9-Atmosphères : composition – 10-Petits corps – 11-Magnétosphère des planètes – 12-Relations étoile-planètes – 13-Orbites planétaires – 14-Flux et spectre – 15-Polarisation – 16-Mesure de plasmas – 17-Flux UV – 18-Imagerie planétaire – 19-Détection des Exoplanètes : Méthode des vitesses radiales et astrométrie – 20-Transits – 21-Habitabilité des (exo)planètes – 22-Exobiologie – 23-Origine de la vie sur Terre.

Several interactive tools have been created for these modules, in particular in the frame of the mini-projects. One example of crater formation is given in Fig. 2. **Navarro** et al. and **Turbet** et al. will also present two other examples in this session.

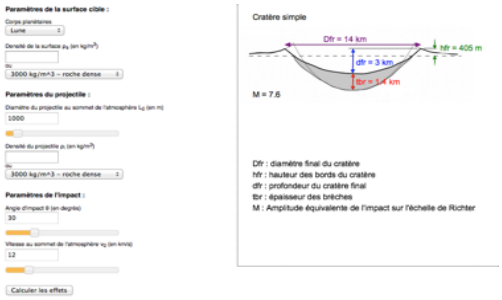

Figure 2: Applet of impact crater simulation (A. Le Gall and C. Schott)

3. « Les exoplanètes »

The website *Les exoplanètes* has been created in the context of the SESP project to replace the obsolete multilingual website *Exoplanètes* [4] created in 2005 but still very much used (3,500 Google hits). The new website is built around a catalogue of exoplanets, which is a simplified mirror site of the research catalogue of the Encyclopedia exoplanet.eu. It is less complete than the research catalogue; however it is up to date with the latest discoverd exoplanets. Whenever possible, the catalogue computes an equilibrium temperature (assuming a zero albedo) and the planet density. In addition to the catalogue, this new website contains visualization tools to work on the data, a histogram and a 4-parameter diagram (Fig. 3). Commented diagrams show how these statistical tools allow exploring the exoplanetary systems' properties and the outstanding issues.

The site contains a table of exoplanet families, an exoplanet counter, 2D and 3D sky maps, and small chapters answering questions about exoplanet definitions, discovery methods, habitability… A 3D simulator shows the structure of all the exoplanetary systems and compares it with the solar system and displays the habitable zone.

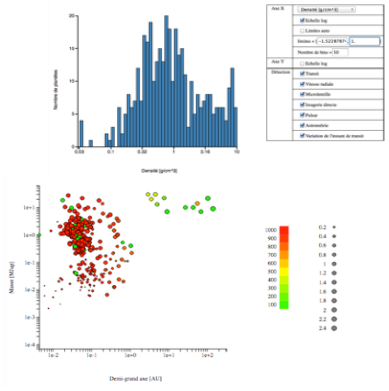

Figure 3: *Top* Histogram of the planet densities. *Bottom* Diagram of the semi-major axis as a function of mass-radius (size) with equilibrium temperature (color). (F. Roques and C. Schott)

4. Future: E-learning projects

After their launch in October 2015, the websites will be used in the L1 to L3 degrees of the partner universities. Further chapters will be added to the SESP website. Projects of distance training are under discussion.

The website *Les Exoplanètes* will be used for remote training including evaluation, taking advantage of the experience of the Paris Observatory. Moreover, we plan to translate the site into English. A collaboration with the Michigan State University could lead to a Summer School based on this website.

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