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Education and Outreach activities in the framework of the Spanish Virtual Observatory

Enrique Solano[1,2] and Carlos Rodrigo[1,2]

[1] Departamento de Astrofísica. Centro de Astrobiología. P.O.Box 78. 28691. Villanueva de la Cañada, Madrid, Spain
[2] Spanish Virtual Observatory

Abstract

In this paper we will describe the main education and outreach activities that are being conducted in the framework of the Spanish Virtual Observatory. In particular, we will outline the scientific and technical activities that are being done in collaboration with astronomical amateurs as well as the citizen science project to improve the orbits of near Earth asteroids using archive images.

1 Introduction

The main objective of the Virtual Observatory[1] is to guarantee an easy and efficient access and analysis of the information hosted in astronomical archives. The Spanish Virtual Observatory (SVO[2]) is a project that was born in 2004 with the goal of promoting and coordinating the VO-related activities at national level. In the next sections we will describe the activities the Spanish Virtual Observatory is conducted towards educators, astronomical amateurs and the general public. In all these activities we use VO capabilities (simplified in some cases) to enable these communities to investigate the Universe.

2 Education activities

The ways in which we contact the early career community are the following:

- Participation in master courses in Astronomy.

[1] http://www.ivoa.net
[2] http://svo.cab.inta-csic.es

The involvement of the new generations of astronomers is a must to ensure the long-term sustainability of the Virtual Observatory. This is why, since 2002, we are conducting master courses on Virtual Observatories at different Spanish universities (Complutense of Madrid, Granada, Valencian International University).

- Supervision of research works.

  The first SVO thesis [1] was defended in 2009. At the time of writing there are two other ongoing thesis (M. Aberasturi "*Identification and characterization of low mass stars and brown dwarfs using the Virtual Observatory*"; A. Aller "*Nebulosas planetarias con estrellas centrales enanas calientes tipo O*") whose defense will occur in 2015. Master thesis and research works both at graduate and undergraduate level have also been supervised by SVO staff.

- Teaching astronomy at undergraduate levels.

  We have taken advantage of the use cases developed in the framework of the Euro-VO project to teach astronomy in undergraduate courses. Suppose, for instance, we want to explain the H-R diagram. Rather than using a static picture, we believe that it is much more illustrative and attractive for the students to use real data gathered from astronomical archives (e.g. the Hipparcos catalogue) and build their own diagram. This is one of the tutorials available from the SVO portal[3]. The determination of proper motion, the estimation of distances to stars in other galaxies, the identification of a supernovae or the classification of galaxies using the Hubble sequence are some of the topics proposed in the tutorials.

3 Outreach activities

- Pro-Am technical collaborations: Implementation of a VO archive for the amateur astronomical community.

  The easier access of amateur astronomers to high-level instrumentation has boosted their participation in real science initiatives through Pro-Am (professional-amateur) collaborations. Typically, these are projects that require long runs of observations (study of variable phenomena, light pollution, discovery of solar system objects,...), something difficult to get in bigger, professional infrastructures. These large datasets can be of interest for many groups and for even different purposes but, in most of occasions, they are inefficiently managed and rarely available on line.

  In the Spanish Virtual Observatory we have developed a VO-archive[4] (Fig. 1) specially suited for amateurs astronomers. In particular it includes light curves from the Spanish network on light pollution[5]. Light pollution monitoring is important not only to identify dark areas for future location of astronomical infrastructures but also, among other

[3] http://svo.cab.inta-csic.es/docs/index.php?pagename=Education/VOcases
[4] http://sdc.cab.inta-csic.es/pdd/jsp/busSQM.jsp
[5] http://guaix.fis.ucm.es/splpr/

Figure 1: Search form of the SVO sky brightness archive.

fields, to understand the influence of light at night in the ecosystems and the human health or for the efficient use of energy.

The observing methodology is very simple. The observers just need to place a photometer pointing toward the cenit and make continuously measurements of the sky brightness. Once the observing run has finished, observers from the different stations of the network have to upload their observations to the archive using a very simple form. Among other functionalities, the archive allows light curve visualisation before downloading (Fig. 2). Data are described following the standard data model agreed by this community[6].

- Pro-Am scientific collaborations: Discovery of common proper motion systems.

  Binary stars are important objects in astrophysics for several reasons like, for instance, their impact on star formation and evolution theories or on the determination of physical parameters (e.g. stellar mass). Although numerous lists of binaries have been compiled since many years ago (see, for instance, the Washington Double Star Catalogue,WDS), there are thousands of uncatalogued systems still hidden in astronomical archives.

  The Garraf Observatory, an amateur observatory near Barcelona with a long tradition in the discovery of binary stars, is carrying out an all-sky survey of common proper-motion stars by comparing POSS I and POSS II images. We are using VO capabilities to dig in these resources and efficiently extract as many new binaries as possible. In particular, we built a VO workflow based on the Aladin[7] scripting capabilities (Fig. 3)

[6]http://www.darksky.org/NSBM/sdf1.0.pdf
[7]http://aladin.u-strasbg.fr/

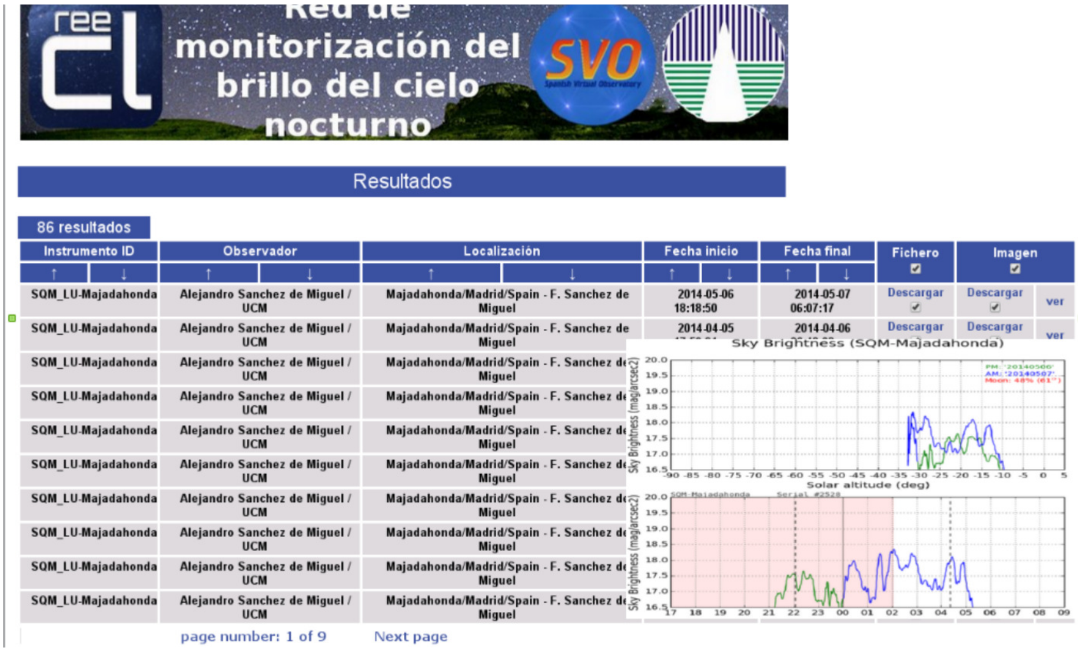

Figure 2: Result of a query and visualization of results in the SVO sky brightness archive.

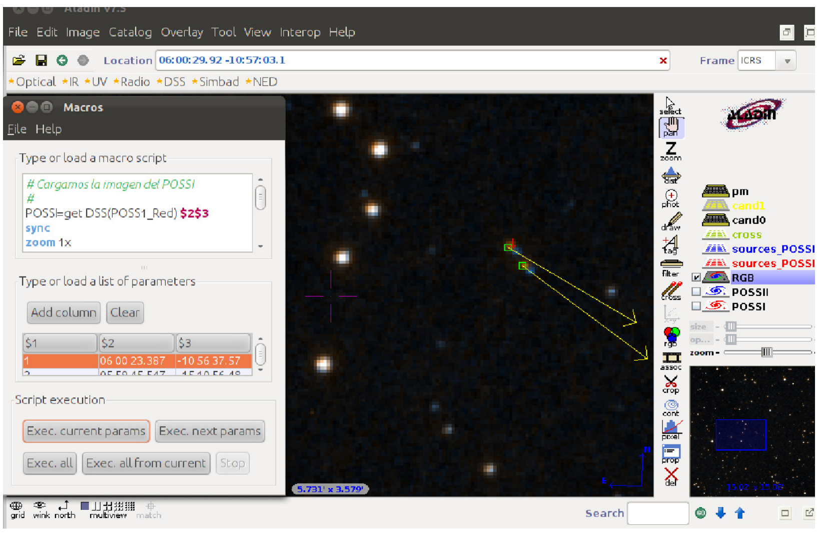

Figure 3: Snapshot of the Aladin script used to discover common proper motion systems in POSS I and POSS II images.

which allowed the discovery of almost 1 700 new common proper motion systems only in the Northern hemisphere.

Also remarkable is that this work has provided side benefits as the discovery of seven weakly bounded, low mass pairs whose analysis is going to be published in a refereed paper.

- Citizen Science: Discovery of near Earth asteroids (NEAs) in astronomical archives.

  Citizen-science can be defined as scientific research conducted, in whole or in part, by amateur or non-professional scientists, often by crowd-sourcing. In July 2011 we started a citizen science program[8] [2] of characterization of the orbit of a large number of near-Earth and Mars-crosser asteroids using SDSS images. One of the most attractive aspects to the general public of asteroid-related projects is the estimation of the risk level of a potential collision with the Earth as well as the mitigation strategies that may be adopted if necessary.

  Discovery alone is not enough to quantify the threat level of a NEA. Above all, it is necessary to compute reliable orbits through accurate astrometric positions covering a period of time as long as possible. Archival data can play a key role in the characterization of the asteroid orbits as almost every single image taken by the most important ground and space-based astronomical observatories eventually end up in open archives, freely available on the web. The main advantage of archive identifications against follow-up observations is that, with a single or very few observations, is possible to significantly extend the arc length and derive an accurate orbit. In particular, the SDSS archive represents an immensely data-rich field where the general public can significantly contribute, mainly in projects related to pattern recognition where the visual inspection has proved exceptionally good.

  With this project we give the public the opportunity to participate in an attractive initiative going through the same steps as professional astronomers (data acquisition, data analysis and publication of results) and making useful contributions to fundamental planetary science and to a better knowledge of potential threats of collision with the Earth. Through visual inspection of sequences of images, users identify the asteroid and measure its coordinates using Aladin (Fig. 4). After passing a number of quality checks, the asteroid positions are sent to the IAU Minor Planet Center to improve the associated orbital parameters.

  Since the public release of the system more than 3 500 users have participated in it and over 350 000 astrometric measurements corresponding to more than 1 000 NEAs and Mars-crossers (17% of the total census) have been realized. Among other results we highlight the identification of more than 150 NEAs and Mars-crossers in images predating their official discovery, by more than 1 000 days for more than 50 of them! It is important to remark that none of these asteroids were detected by the SDSS photometric pipeline which clearly stresses the success of the project. We are presently working in the improvements of the capabilities of the system, in particular the mechanisms to

[8] http://www.laeff.cab.inta-csic.es/projects/near/

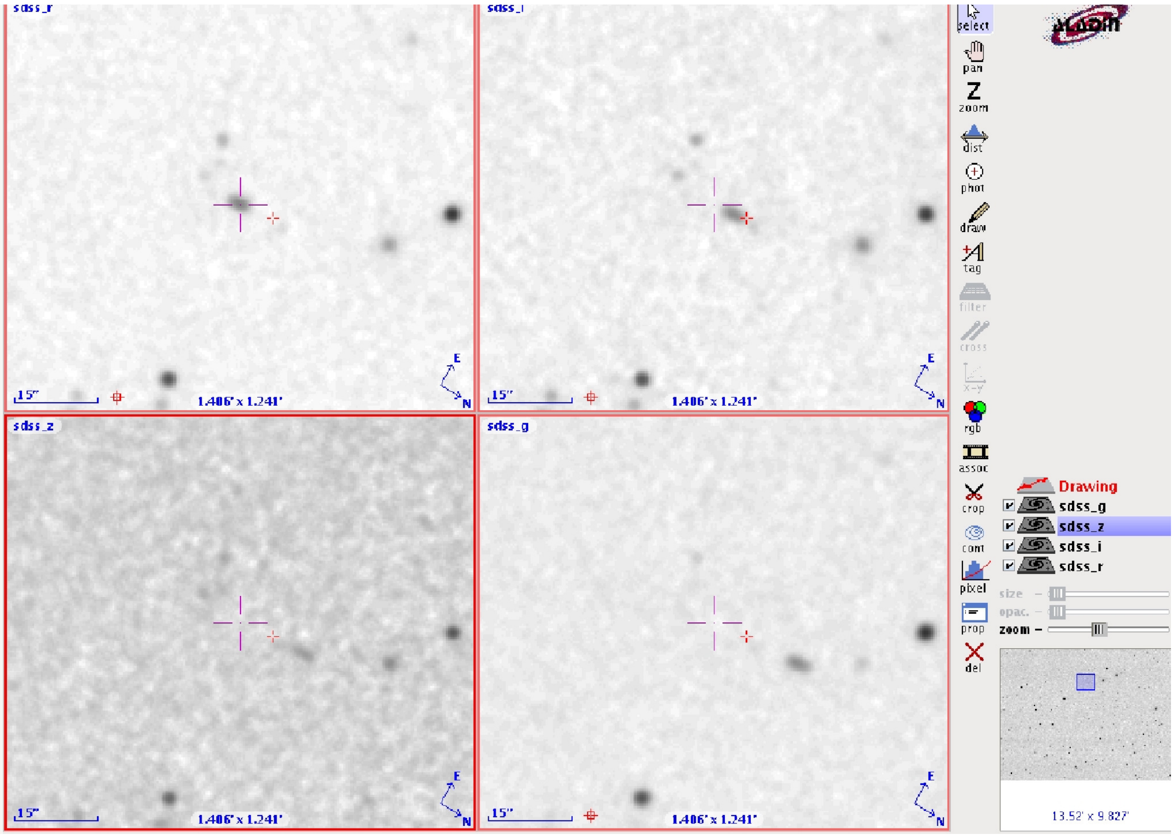

Figure 4: Asteroid identification. The motion of the asteroid makes it easily detectable in the sequence of SDSS images in Aladin.

exchange information with the users. Moreover, new surveys in different wavelength ranges (VISTA/VHS, VST/ATLAS, UKIDSS) will be incorporated which will open the door to new discoveries.

Acknowledgments

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References

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