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CESAR: A ROBOTIC TELESCOPE NETWORK TO SCIENCE AND PUBLIC OUTREACH

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RESUMEN

CESAR es una red de instalaciones astronómicas que pone a disposición de la sociedad una amplia variedad de telescopios que cubre la mayoría de las técnicas observacionales, desde la Radioastronomía hasta el óptico, incluyendo la observación solar. Al menos estarán disponibles para este proyecto cinco telescopios.

ABSTRACT

CESAR is a new network for astronomy that put available some telescopes covering most of the observational techniques, from radioastronomy to optical astronomy, including solar observation. At least five astronomical telescopes will be ready for this project.

Key Words: telescopes — education

1. INTRODUCTION

1.1. *What is CESAR?*

CESAR (Cooperation through Education in Science and Astronomy Research) (see CESAR 2014) is a joint educational programme developed by ESA, INTA and ISDEFE. The aim of this project (see Sánchez et al. 2009) is to provide students from European secondary schools and universities with hands-on experience in Astronomy research in general and in Radio Astronomy and Optical Astronomy in particular (see Baruch et al. 1992).

CESAR's educational project should not only be of didactic value but should produce also real scientific results within the framework of its limited resources (see Vaquerizo & Cabezas 2013; Cuesta 2008a). In addition, as secondary objective, CESAR shall contribute with outreach activities to promote Space Science and to stimulate European student's interest in Science and Technology in general and Astronomy in particular.

2. THE ASTRONOMICAL NETWORK

CESAR counts currently with three observatories: ESAC Observatory, Robledo de Chavela Observatory and Cebreros Observatory, where all the five telescopes are distributed wiht different wavelength ranges.

It is also foreseen to set up a network of partner telescopes willing to join this initiative and donate observing time of their instruments to didactical and scientific programmes. The first to join will most probably be the PARTNeR (see Blasco & Vaquerizo 2008; Vaquerizo 2010) radio telescope situated at the NASA Madrid Deep Space Communications Complex.

Fig. 1. 50cm Optical Telescope in Cebreros.

2.1. *Optical Astronomy*

2.1.1. *Optical Telescope at Cebreros*

The Cebreros Optical Telescope is a 50cm optical robotic telescope (see Cuesta 2008b; Cuesta et al. 2010) placed at ESAs Deep Space Tracking Station, located near Cebreros (Ávila) (see Figure 1).

The telescope is equipped with a 4008×2672 refrigerated CCD Finger Lakes with a pixel size of 9μm that covers a field of $24' \times 16'$ with a pixel projection of $0.37''$/pixel. This is a cooled monochrome interline array manufactured by Kodak (KAI-11002) optimized for speed readout (12MHz) and a shutter capable of 0.05-second exposures. The teelscope is also equiped with a filter wheel with the typical UBVRI Johnson photometry set, nebular filters (OIII, Hα, and Hβ), and red, green, and blue filters.

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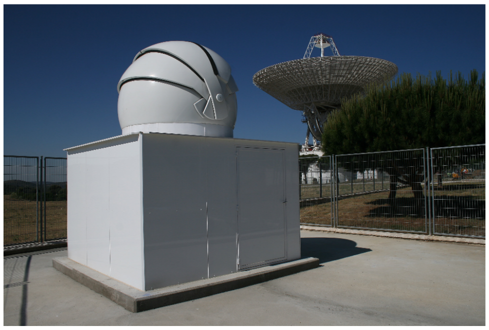

Fig. 2. 30cm Optical Telescope in Robledo.

Fig. 3. 15m VIL-1 antenna in ESAC.

The observatory is controlled using the LINUX-based Talon software from Optical Mechanics, Inc. This application controls the observatory subsystems: telescope, dome, filter wheel, temperature corrected focus, weather station and CCD camera. This robotic telescopes operates in queue-based mode.

2.1.2. *Optical Telescope at Robledo*

The Robledo Optical Telescope (see Sánchez et al. 2009) is a 30cm MEADE optical telescope located at the visitors centre of the NASA Deep Space Network ground station in Robledo de Chavela (Madrid, Spain) (see Figure 2). This telescopes operates in real time and queue-based modes.

2.2. *Radio Astronomy*

The ESAC Radio Telescope (see Figure 3) is composed by the ESAC VIL-1 S-Band Antenna connected to an AGILENT Power Meter (see Sánchez et al. 2009). The S-band transmitter and S-band receiver (S/S) Cassegrain antenna is fitted with a shaped 15m parabolic main reflector and a shaped hyperbolic sub-reflector in an elevation over azimuth mount. The half-power beam width (HPBM) is $36'$ which is slightly bigger that the angular size of the Moon ($30.5'$).

Fig. 4. 9cm Solar Telescope in ESAC.

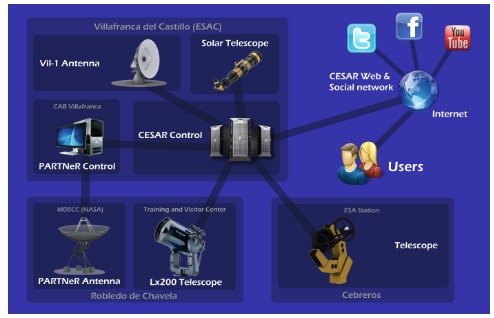

Fig. 5. Architecture of the CESAR project.

2.3. *Solar Astronomy*

2.3.1. *Solar Telescope at Robledo*

The Robledo Solar Telescope is a 9cm Hα telescope together with a small 10cm refractor installed at the visitors centre of the NASA Deep Space Network ground station in Robledo de Chavela (Madrid, Spain) to perform solar observations during the day. This telescopes operates in real time and queue-based modes.

2.3.2. *Solar Telescope at ESAC*

The ESAC Solar Telescope (see Figure 4) is a 9cm Hα telescope together with a small 10cm refractor installed at ESAC to perform solar observations during the day. This telescopes operates in real time and queue-based modes.

2.4. *Control Room Observatory*

From the CESAR Main Control Centre is possible to connect and control all participating telescopes. Also, all the observation data is transferred there in order to archive and distribute to the users. The Control Centre will be split in two modules: the control module and the CESAR Data Archive.

Apart from the five astronomical installations mentioned also will be possible to access to the PARTNeR project control in Centro de Astrobiología, a radioastronomy established project.

Using 4 computers and 2 servers (see Figure 5), this Control Room will provide all CESARs information to the students, via website and social networks.

3. EDUCATION APPROACH

CESAR is a project with a clear educational vocation. Then, the idea is to provide open telescopes to the public. There is a complete educational program related with CESAR and his five astronomical instalations. See Vaquerizo & Cuesta (2014) for more information.

4. OBSERVATION PROGRAMS

Behind the educational vocation of CESAR project there are a large number of scientific programs taking use of the complete observational capabilities of all the five telescopes. The scienctific programs range from the Astrobiology perspective (Exoplanets, Asteroids, Comets and NEOs) to some other very interesting lines (solar study, supernovae, X-Ray binaries, etc.).

Attending the characteristics of the project, from the observational point of view they can divide into: Optical Astronomy, Solar Observation and Radio Oservation.

4.1. *Optical Astronomy*

4.1.1. *Photometric detection and confirmation for extrasolar planets*

Extrasolar planets (or exoplanets) have been extensively searched during the last two decades. As a result of this effort, since 1995 –when the first exoplanet was discovered (Mayor & Queloz 1995, 1996; Marcy & Butler 1996)– there are now near 1000 confirmed exoplanets.

Most of the planets have been detected with the radial velocity method. The second most productive indirect technique of detection is the transit method. When a planet crosses (or transits) in front of its parent star, the observed brightness of the star drops by a small amount. The amount by which the star dims depends on its size and on the size of the planet, among other factors (see Cuesta, Eibe, & Ullán 2011, Eibe et al. 2012).

Not only is the search for exoplanets important but also the characterization is a goal. In this sense, we will develop a reliable database of parameters for exoplanets. The working method is to use the telescope for monitoring beforehand selected stars by fast optical photometry (see Eibe et al. 2011, Cuesta 2010). We will observe stars with known transit exoplanets to obtain a light curve from which information about its parameters may be extracted. The repeated observation of these transits will substantially reduce the error bars and will provide a data set with increasing accuracy so that they can be collated, thus allowing to draw conclusions about the nature of exoplanets and its formation conditions.

4.1.2. *Supernovae Detection in Nearby Galaxies*

Supernovae are bright enough to be observed at cosmologically important distances, thereby increasing their significance in the search for those parameters governing the expansion rate of the universe (i.e. Hubble constant).

Early detection of supernovae explosions is important to get vital spectroscopic information for type classification while the system is still bright and spectroscopy still possible. Is also important the observation of the outburst maximum light, which gives information about its distance. Assuming the luminosity can be established for the type Ia supernovae, its absolute magnitude is then known.

The telescope is going to systematically monitor several hundreds of spiral galaxies that lie less than 300 million light years from our Milky Way. Rapid identification can take place without the need for exhaustive photometry and data analysis, or relying on memorization of many star fields.

4.1.3. *Asteroids rotation*

Lightcurves of asteroids obtained with small telescopes provide strong constraints on the spin and 3-D shape of asteroids. The multi-data inversion method dubbed KOALA (Carry et al. 2011) allows to reconstruct the 3-D shape of small bodies of our Solar System from the ground to an unprecedented level of accuracy and realism. Determination of the spin, size, and 3-D shape of asteroids has far-reaching implications in our understanding of the formation and evolution processes of the planetesimals that accreted to form telluric planets. This implies large observing campaigns of many asteroids. Small robotic telescopes are a key instrumentation in such a program: the lightcurves data they provide are highly valuable.

4.2. *Solar observation*

In the 19th century it became clear that the number of sunspots was related to the solar activity and undergoing a cyclic change. Since then sunspots are counted systematically by various observatories around the globe and define cycle of solar activity. With the CESAR solar telescope, taking pictures every week, we can participate in the world wide campaign of sunspot counting.

Sunspots cannot only be used to measure the activity of the Sun but also its rotation. Since the 17th century the moving of sunspots across the solar disc was observed by astronomers and used to measure the equatorial rotation of the sun. These observations also led to the discovery that the Sun rotation was slower at higher latitudes than on the solar equator (= differential rotation of the Sun). With the CESAR solar telescope, taking pictures every week, we can determine the solar differential rotation.

4.3. *Radio observation*

Radio astronomy is a subfield of astronomy that studies celestial objects at radio frequencies. These sources of radio emission include stars and galaxies, as well as entirely new classes of objects, such as radio galaxies, quasars, pulsars, and masers. Radio astronomy is conducted using large radio antennas referred to as radio telescopes.

4.3.1. *X-Ray binaries*

The aim of this project is the monitoring of a special type of X-ray binaries, also known as microquasars, at radio wavelengths. An X-ray binary consists of a compact object (black hole or neutron star) and a "normal" star, swallowed by the compact object. Some of these systems show radio bursts and their study can give us information about the black hole/neutron star, accretion rate, etc. Students will perform observations of a few selected microquasars to obtain a long-term data set of their radio fluxes, searching for flares. Students will then participate in a "Radio Burst Patrol", rendering the scientific community a valuable service.

4.3.2. *Jupiter Magnetosphere Study*

The radiation at radio wavelengths coming from Jupiter is thermal emission of the planet plus the non-thermal emission coming from high energy electrons trapped in its surrounding magnetosphere. Due to a misalignment of spin and magnetic axes of Jupiter, the non-thermal intensity varies with the rotation of the planet. Since the rotation period is about 10 hours, systematic observations will allow students to measure the periodic power variation also known as Beaming Curve (see Vaquerizo et al. 2010).

The project objective is to seek non-thermal variability caused by other causes unrelated to the Jovian magnetic field, such as variations in solar activity or possible changes induced in the planet for great asteroid and comet impacts.

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