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A PRIMER FOR THE SAN PEDRO MÁRTIR OBSERVATORY

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RESUMEN

El Observatorio Astronómico Nacional es administrado y operado por el Instituto de Astronomía de la UNAM. Se localiza en el norte del país, en la sierra San Pedro Mártir (SPM), en el estado de Baja California. Ubicado a una altitud de 2890 m sobre el nivel del mar, a 31° de latitud norte, flanqueado por el Oceano Pacífico y el golfo de Baja California, SPM ha demostrado ser uno de los últimos lugares prístinos para un observatorio astronómico en nuestro planeta. El IAUNAM está haciendo esfuerzos substanciales en materia de conservación y desarrollo de este excelente sitio astronómico. Presentamos aquí una breve semblanza de sus características y recursos.

ABSTRACT

The Observatorio Astronómico Nacional is run and operated by the Instituto de Astronomía of the National Autonomous University of Mexico. It is located in the northern part of México, in the sierra San Pedro Mártir (SPM), in the state of Baja California. At an altitude of 2890 m above sea level, 31° north in latitude, flanked by the Pacific Ocean and the gulf of Baja California, SPM has proven to be one of the last pristine spots for a ground-based astronomical observatory in our planet. The IAUNAM is making substantial efforts towards conservation and further development of this excellent astronomical site. Here we present a brief account of its basic characteristics and facilities.

Key Words: **INSTRUMENTATION — SITE TESTING**

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1. INTRODUCTION

The Observatorio Astronómico Nacional (OAN) was established one hundred and twenty five years ago, in 1878. It was first housed in the Castillo de Chapultepec and later moved to Tacubaya, in the outskirts of Mexico City. The fast growth of the city in the early decades of the past century forced a second move for the OAN, this time out of Mexico City, to the small town of Tonantzintla in the state of Puebla. Tonantzintla's convenient geographic location at $\sim$19° north and the clear skies of the place in those days gave the observatory a distinct advantage for it was able to observe much of the southern sky in addition to the northern hemisphere. Some beautiful images of the Carina nebula ($\delta = -59°$) taken from Tonantzintla still remain from those times. However, and again, the fast growing city of Puebla, located just some 30 km away from Tonantzintla and its increasing light pollution soon would render the site useless for deep sky astronomy. A survey of the national territory aimed to find an appropriate new location for the OAN quickly revealed the sierra San Pedro Mártir (SPM) in the state of Baja California as the best possible site. In those days the parameters considered were mainly the percentage of clear, photometric, nights and its relative isolation from fast-growing urban centers. The National Autonomous University of Mexico (UNAM) started of the first building construction at SPM in 1967. As time has gone by, SPM has proven to be one of the best astronomical sites in the world, exceeding all the best initial expectations. This volume is dedicated to describe our current knowledge of SPM as an astronomical site. In this contribution we shall start by describing the main current facilities of the OAN. OAN information and web pages can be accessed at `http://www.astroscu.unam.mx`, `http://www.astrosen.unam.mx` or `http://132.248.3.38/Opciones/text1.html`.

2. TELESCOPES

The OAN has three telescopes in operation, with main optics diameters of 2.1-, 1.5-, and 0.84-m. These telescopes have served well the astronomical and technical community of the Instituto de Astronomía of the UNAM (IAUNAM) for the past 25 years. Generations of Mexican astronomers have learned the intricacies of observing at SPM and much of the observational research from UNAM astronomers and from other Mexican institutions, has been carried out at SPM. The OAN technical staff

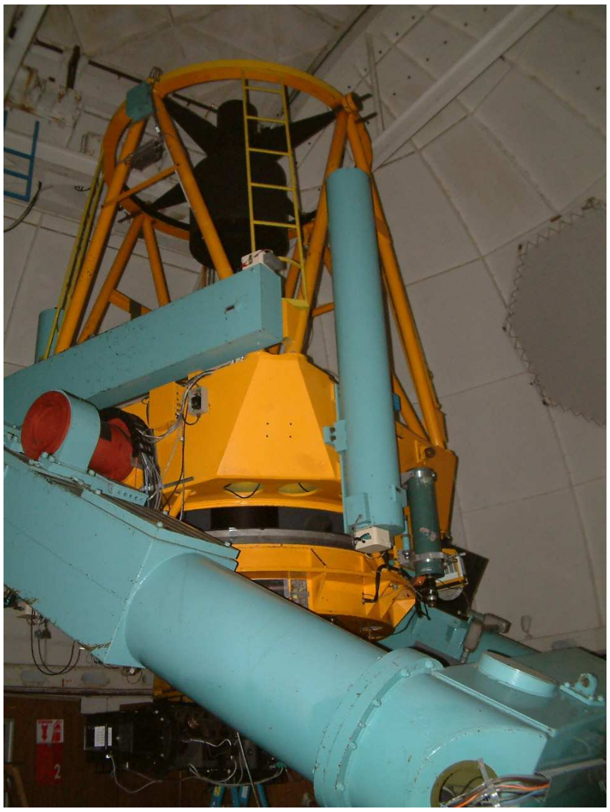

Fig. 1. A view of the 2.1 m SPM telescope.

makes a fine job at keeping the telescopes running, developing new instrumentation and constantly upgrading existing instruments. The deep dark sky of SPM, its large percentage of clear nights, low relative humidity and atmospheric turbulence, together with a relatively good suite of associated instruments at the telescopes, and generous allocations of telescope time, has all helped Mexican astronomers to keep competitive. However, it is clear that this battery of old and small telescopes is nowadays insufficient for modern astronomical research. The IAUNAM has been pursuing for nearly a decade a project to build a large, new technology telescope that can take proper advantage of the exceptional characteristics of the site and satisfy the demands of Mexican astronomy in the optical and infrared bands for the coming decades.

3. INSTRUMENTATION

One of the main tools to keep the OAN competitive in the last years has been the associated instrumentation at the telescopes. The OAN has a number of photometric, spectroscopic and imaging capabilities in the optical and infrared domains. These instruments have been either built in-house or operated under collaborative agreements with other institutions. A brief description of these instruments is given below.

3.1. *Optical spectroscopy*

Low and high spectral resolution spectrometers are available at the OAN. For low and intermediate resolution there is a Boller & Chivens spectrometer, property of the Osservatorio Astronomico di Brera and operated under agreement with the Italian colleagues by the OAN. A number of gratings are available for this instrument providing spectral resolutions from 1.6 to 12.8 Å and covering the full optical range. This spectrometer is used at the 2.1 m telescope. A second, smaller, B & Ch spectrometer, property of the OAN, is available for use in the other two telescopes.

In the high spectral resolution domain, the OAN has three instruments for the 2.1 m telescope. One is a classical multi-order Echelle spectrometer with cross dispersor, made by REOSC and having a resolving power R = 18000 at 5000 Å yielding a resolution of 17 km s^{-1}.

A second Echelle spectrometer, suited for the study of extended nebular sources, is the Manchester Echelle spectrometer (MES-SPM), operated under collaboration with the University of Manchester, UK. This is an spectrometer with no cross-dispersor that isolates individual Echelle orders with interference filters, $\sim$ 100 Å wide, to obtain spatially resolved profiles from faint, extended sources emitting in the range 3900 – 9000 Å and capable of a resolving power $\leq 10^5$. This spectrometer can operate in single or multi long-slit mode, with the length of the slit covering $5'$ on the sky.

Thirdly, the OAN also has a stepped Fabry-Perot interferometer (PUMA) built by the IAUNAM, with a $10'$ field of view. It is also ideal for the study of extended sources and yields a typical spectral resolution of 19 km s^{-1} at Hα.

3.2. *Optical Imaging*

Dedicated cameras with automated filter wheels are available at the three telescopes. These systems include broad and narrow band imaging capabilities with a rather good set of filters for galactic and extragalactic studies.

3.3. *Infrared Imaging and spectroscopy*

For direct imaging and spectroscopy in the near infrared regime (1 – 2.5 μm) the IAUNAM built CAMILA, a camera – spectrometer that has a NICMOS 3, 256×256 pixels detector. In the direct imaging mode, it has two cameras with different focal ratios for fields of view $1.28' \times 1.28'$ and $3.63' \times 3.63'$,

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respectively. In the spectroscopic mode, the available spectral resolutions are R=1500 and R=500 at 2 μm. An optional polarizer and an infrared scanning Fabry-Pérot can be inserted for either polarization or integral field spectroscopy NIR studies. The detector controller was designed at IAUNAM. CAMILA has been operating for over ten years and is expected to be upgraded with a HAWAII (1024×1024 pixels) detector next year.

Additionally, the OAN has a double infrared camera, dubbed CID, for the near and mid-infrared bands. This camera operates with two independent instruments/detectors, namely the CID-InSb and the CID-BIB, both sharing the same cryogenic housing. CID-InSb has a Santa Barbara 256×256 array with 30 μm pixels sensitive from 1 – 5 μm and can perform both, direct imaging with a field of view $1.7' \times 1.7'$ and low resolution spectroscopy with spectral resolutions R = 1400 at 2.2 μm and R = 500 and 1200 at 3.6 μm. The CID-BIB is a mid-infrared camera optimized to 10 μm with a filter collection, which uses a BIB detector (Boeing) 128×128 with 75 μm pixels, sensitive from 2 to 27 μm.

3.4. *Photometry*

Apart from 2–D photometry that can be performed from direct imaging CCD data, the OAN has two stellar photometers. One is a six-channel spectrophotometer operating in the $uvby-\beta$ Strömgren system. It was built by Copenhagen University and is nowadays property of the OAN. This instrument has two operating modes to record data in the *uvby* bands simultaneously by the use of a diffraction grating. A second mode of operation measures Hβ in broad and narrow passbands. The instrument has two sets of photo-multipliers from Electron Tubes and it has been recently modified and upgraded by the OAN technical staff.

There is also a monochannel photometer equipped with a RCA C31034A-02 photo-multiplier, known as the Lowell photometer. It has a motorized filter wheel with eight positions available. The $UBVRI$ filters are usually mounted in this photometer.

3.5. *Charge coupled devices, consoles, instrument control and user interfaces*

The OAN currently has in operation 4 CCD detectors. These are a Thomson 2048×2048 with 15 μm pixels and three SITe 1024×1024 with 24 μm pixels. The Thomson, Site 1 and Site 3 detectors are cryogenic systems built by Photometrics, now Roper, whereas the Site 2 has a three stage Peltier thermoelectric cooler built by Pixel Vision. A fifth CCD system, with a 2048×2048 Marconi chip with 13.5 μm pixels will be available at the OAN by the end of 2003. CCD controllers are under development at the IAUNAM.

Consoles driving the telescopes at the OAN have been designed and built by the OAN technical staff as are the remote control systems and user interfaces for all the instruments operating at the OAN.

4. THE ROAD TO SPM

Selecting a site that is relatively isolated and thus shielded from urban pollution implies a constant toll in terms of transportation costs and time. Yet this price is worth paying in the case of an astronomical observatory such as SPM. The IAUNAM has a research branch in the nearby city of Ensenada with a staff of 25 astronomers, a similar number of technical staff and students. The IAUNAM-Ensenada also serves as the logistic and administrative station for the OAN. Ensenada is located 110 km south of the San Diego-Tijuana border. The OAN is 145 km south and 100 km east from Ensenada. However, the journey for these 245 km takes from 4 to 5 hours. The last 80 km of the road, as one climbs the sierra, are unpaved. The UNAM maintains the last 50 km of this road and is currently seeking from the federal and state governments support to pave the entire road to the OAN. At the observatory, the lodge and workshops are located 4 km away from the telescopes. The road from the lodge to the telescope area has been paved and is maintained also by the UNAM. During the winter months the weather can be rather cold at SPM and occasional snow storms may block the road. The OAN owns heavy machinery that keeps at the observatory to clean and give regular maintenance to the road.

5. ELECTRIC POWER, FUEL, WATER AND LIQUID NITROGEN

Public electric lines do not reach SPM. Electric power is generated at the OAN with diesel generators. The OAN has five electric generators with power capacity of 280, 230, 200, 150, and 90 kw, respectively. The smaller ones are used as emergency plants. Diesel and gasoline are transported to the OAN in a 15000 l pipe truck property of the OAN. The OAN has storage tanks with a capacity of 75000 l for diesel and 25000 l for gasoline. Another dedicated pipe truck transports water daily to the observatory from a nearby well to an storage tank and two smaller pipe trucks distribute it to the different areas within the OAN. To supply liquid nitrogen to

Fig. 2. A bird's-eye view of the telescope zone at the OAN-SPM. In the foreground is the 1.5 m telescope, followed by the 0.84 m telescope in the middle and the 2.1 m telescope in the background.

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the CCDs that operate on the three telescopes, the OAN has a liquid nitrogen liquefier that produces 100 l/day of N_2.

6. VEHICLES AND HEAVY MACHINERY

A total of 31 vehicles, including trucks, pick-ups, vans and cars are operated by the OAN and the IAUNAM-Ensenada. These are used to transport staff and visitors to the OAN and back to Ensenada, as well as regular supplies for the operation of the OAN and the activities in Ensenada. Some of these vehicles reside permanently at the observatory for different activities, some are assigned to astronomers, others to the technical and support staff. Two excavators, two motor graders, one D8 tractor and a large crane also reside at the observatory performing a number of support and maintenance activities all year round.

7. THE LODGE

Seven individual igloo-type units served until recently as dormitories, offices, laundry, kitchen, dinning room, library and TV and games room. All these have now been replaced by a new, 2000 m^2 modern building that contains all the above facilities, including now also a public computer room with access to Internet and a small gym.

8. TELEPHONE AND DIGITAL COMMUNICATIONS

The OAN has been recently connected to the outside world by a 2 Mbps microwave link that downloads voice and data communications to the regional fiber-optics network of the local telephone company. This link can be upgraded to 16 Mbps. At these rates of data transfer, digital communications are reasonably efficient. All the OAN buildings, such as telescopes, workshops and the lodge are connected

Fig. 3. A view of the new lodge at SPM

via a fiber-optics network. The telephone internal system operates with voice/IP technology over this network. The previous satellite link running at 128 kbps is still in operation as a backup system.

9. THE SPM NATIONAL PARK AND THE OAN

The Sierra San Pedro Mártir is a National Park and as such, federal public land. A Presidential Decree from 1975 declares astronomy of public interest and assigns an area in SPM for the activities of the OAN. A management program for the park is currently under development. In this program, the area where the OAN is now located and the adjacent regions, comprising a total 3200 hectares, will be protected from light and other pollutants potentially harmful to the operation of the OAN. Additional measures to guarantee the operation and future development of the OAN are under discussion with the federal and state governments.

10. THE FUTURE OF THE OAN-SPM

Site testing and statistics of weather conditions have been carried out at SPM with a number of different techniques during the last years. The contributions presented in this volume represent a compilation of results obtained from these studies. These data demonstrate the high quality of SPM as an astronomical site, one of the last remaining appropriate spots in our planet for a ground-based astronomical observatory. Site testing continues at SPM.

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