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THE FIRST YEARS OF OPTICS IN MEXICO AND THE ROLE OF THE BOLETÍN DE LOS OBSERVATORIOS DE TONANTZINTLA Y TACUBAYA ON ITS DEVELOPMENT

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RESUMEN

Históricamente el campo de la Óptica, en México, en términos de proyectos de investigación, desarrollos tecnológicos, y enseñanza, inicialmente a nivel de licenciatura, pero sobre todo a nivel de posgrado, tuvo sus inicios en el Instituto de Astronomía de la UNAM, alrededor del año de 1960. Como consecuencia natural, los primeros trabajos de investigación estuvieron relacionados con publicaciones y la construcción de instrumentos ópticos para la Astronomía. Sin embargo, al mismo tiempo durante esos años iniciales, otras actividades se empezaron a realizar como la construcción de laseres de He-Ne, el depósito de recubrimientos de películas delgadas dieléctricas sobre superficies ópticas, el obtener hologramas, y con propósitos generales producir un programa de diseño óptico para computadoras electrónicas, así como aplicar y desarrollar nuevos métodos de pruebas de superficies e instrumentos ópticos.

ABSTRACT

The field of Optics in Mexico, related with research projects, started at the Instituto de Astronomía, UNAM, since 1960. Therefore, the first projects and papers were mainly dedicated to astronomical instruments. After sometime, other projects started other areas of Optics as for example the production of He-Ne gas lasers, thin films deposits, experiments in holography, programs for general optical design, and theory and experiments for testing optical components and instruments.

Key Words: instrumentation — optics — telescopes

1. GENERAL

The content of this paper is a kind of historical review of how the field of optics started in México, mainly during the period from 1965 to 1980. Hence in § 2 the first five papers in optics published in BOTT are described.Those articles were related with the construction of the optics of a reflection astronomical telescope, Ritchey-Chrêtien, modified Cassegrain, with a diameter of 84 cm in the primary mirror. However, besides those papers, § 3 has the description of two technical reports related to the optical design and construction of such optics; as a matter of fact, the construction and testing of the mirrors were carried out at the Optical Shop of the Instituto de Astronomía. From this first experience, in the next years, the design and construction of optical components were developed; in § 4 the description of the design and construction of a larger astronomical telescope, with a 210 cm diameter in the primary mirror is presented. On the other hand, it is important to mention that after those initial years in optical projects, mentioned above, nowadays other research fields in Optics are under way at several institutions in Mexico, as for example: INAOE (Puebla); Instituto de Astronomía, UNAM (Mexico City); CICESE (Baja California); CIO (Guanajuato); BUAP (Puebla); UAM (Mexico City); CCADET, UNAM (Mexico City); IPN (Mexico City); UNISON (Sonora); UMSNH (Michoacán); ITESM (Nuevo León). Some of the fields in optics that those institutions are working on are, for example, fiber optics, medical applications of optics, quantum optics, diffraction theory, image processing, colorimetry, optical metrology, thin films, etc.

2. OPTICS PUBLICATIONS IN THE BOTT

In this section will be described the five optics papers published in the BOTT, within the period 1965–1970. The importance of those publications is that they are the first articles in optics produced in Mexico. Besides of the mentioned facts, they were the theoretical core for the construction of the optical components of a Ritchey-Chrêtien telescope (Cassegrain type), with a 84 cm in diameter of the primary mirror. The details of the design were done with the computer program described by Malacara & Cornejo (1970a) in a technical report; the full process of the construction of the mirrors and its testing, for

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reaching hyperbolics figures in both mirrors are also fully described in the Technical Report by Cornejo, Malacara, & Castro (1969). In what follows the descriptions of the papers published in the BOTT are given:

I. "Design of Telescopes of the Cassegrain and Ritchey-Chrêtien Types", Malacara (1965a). In this article the general paraxial equations are derived for the design of a Cassegrain telescope in the scheme of a Ritchey-Chrêtien, for improving the correction of the aberrations in order to cover a bigger field of view. The starting point for the design is to consider the parameters of the telescope such as the diameter of the primary mirror, the focal length of both mirrors, the back distance from the vertex of the primary to the Cassegrain focal plane, and the desired size of the image. For the correction of the aberrations, the important parameters to take into account are the conic constants of the two mirrors, according to the proposals made by Ritchey-Chrêtien, as a final result the figures of both mirrors become hyperboloids.

II. "Ronchi Test and Transversal Spherical Aberration", Malacara (1965b). Since at that time, the evaluation of the figure of the optical surfaces started to be analyzed by means of an electronic computer. The analysis and the computation of the theoretical Ronchigramas was proposed; with particular interest for the testing of astronomical devices as: Schmidt correcting plates, and telescope objectives.

III. "Direct Design Solution for Casseegrain Shields", Cornejo & Malacara (1968). For the construction of a Ritchey-Chrêtien telescope, the design of the baffles for both mirrors, was usually solved with numerical techniques. After a review of the publications on the subject, and observing the kind of curves obtained for the solutions, that were mainly second degree curves; these allowed the authors to obtain an analytical paraxial solution. This solution was obtained considering the trajectory of the incident and reflected rays in both mirrors, in such a way that the baffles must avoid direct incident rays to reach the focal plane of the telescope. An important aspect to consider in order to get the final result, was to take flat shapes of both mirrors (Frickle 1969; Michelson 1974; Young 1974).

IV. "Note on the Design of Two Ross Type Photographic Objectives", Cornejo, Castro, & Malacara (1970). With the natural phenomena of a solar eclipse that was observed in Oaxaca, México, in March of 1970, for more than three minutes. A group of astronomers and students at the Institute of Astronomy, UNAM, decided to observe the deviations of the light rays passing close to the sun, proposed by Einstein. The leader of the group was Dr. Emmanuel Mendez Palma, supported with the advice of Prof. S. Vasilevsky. For carrying out such an experiment, two equal photographic objectives and plane mirrors were necessary. Therefore, in order to accomplish the requirements of the experiment, a review of the literature guided the authors to the design of two Ross type photographic objectives. Each system contained two positive lenses, with a diameter of 12.5 cm. An important aspect that had to be satisfied was that both systems must be equal in its construction and mechanical mountings. The optical design was done with the computer program prepared by Malacara & Cornejo (1970a), in a technical report already mentioned, and the lenses and mirrors were constructed and tested in the Optical Shop of the Instituto de Astronomía, UNAM.

V. "A Schmidt-Cassegrain Camera for Use with an Image Intensifier Tube", Cornejo, Malacara, & Cobos (1970). The design of this instrument was also done with the computer program just mentioned before, and the camera was adapted to a Cassegrain spectrograph that is used in the 1 m telescope located in the Observatorio Astronómico Nacional at Tonantzintla, where an image intensifier is connected. In order to have a compact system with correction of the aberrations, and working in the spectral range between 4000–9000 Å. The final design was a Schmidt-Cassegrain Camera, that contains a Schmidt correction plate, two mirrors of a Cassegrain camera, plus a flattener lens coupled with the detector, in order to have a flat focal plane.

3. CONSTRUCTION OF A REFLECTING TELESCOPE RITCHEY-CHRÊTIEN WITH 84 CM IN DIAMETER OF THE PRIMARY MIRROR

In the technical report (Cornejo, Malacara, & Castro 1969) the description of how an older polishing machine, that already existed at the Instituto de Astronomía, UNAM, was modified Also such report contains the procedure for making the hole of the primary mirror with a vertical drill, and the steps for the fine grinding and polishing of primary and

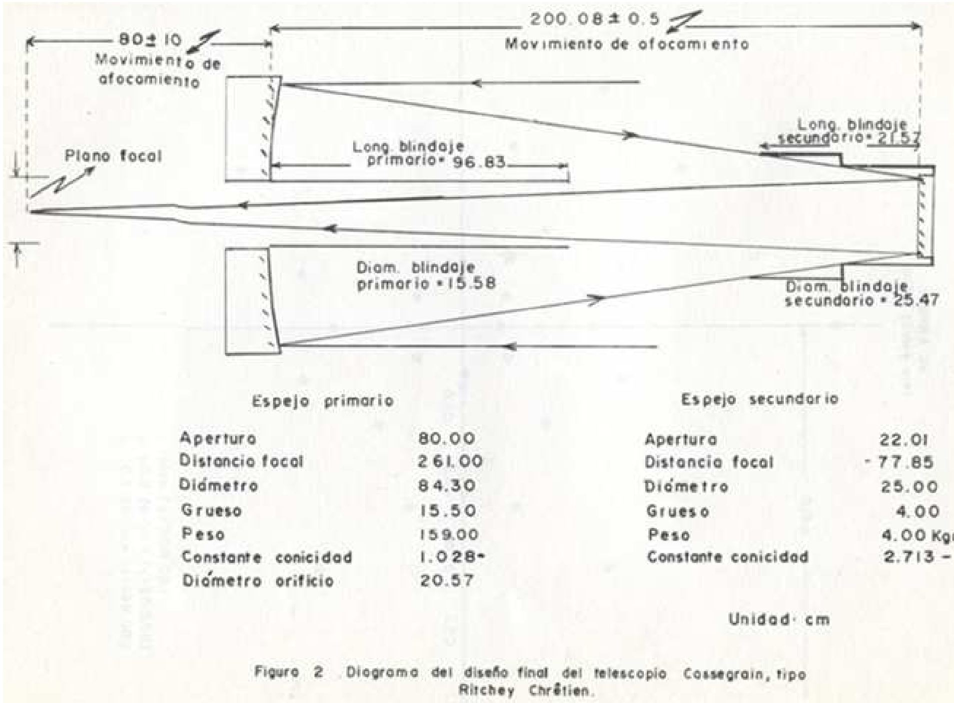

Fig. 1. Final design of the 84 cm Ritchey-Chrêtien telescope.

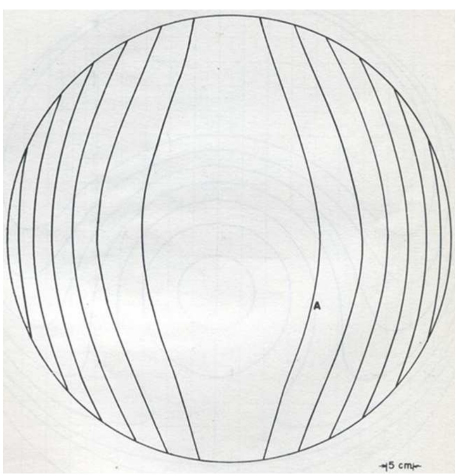

Fig. 2. Theoretical or ideal Ronchigram for testing the primary mirror.

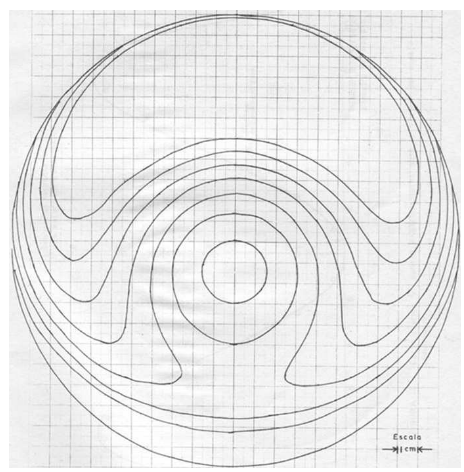

Fig. 3. Interferogram for testing the secondary mirror using Newton rings.

secondary mirrors. The report also contains the description of the testing methods applied, in order to obtain hyperbolic surfaces for the two mirrors of the telescope. As a matter of fact, the test method of the secondary mirror, a convex hyperbolic surface using Newton's rings, was published by Malacara & Cornejo (1970b). In the next list of figures are some photographs about the final design and the different processes for the construction of this 84 cm telescope: in Figure 1 are the parameters of the final optical design; in Figure 2 is the theoretical Ronchigram for the hyperbolic primary mirror; Figure 3 has the Newton fringes for the hyperbolic secondary mirror. Both types of interferograms were calculated with an electronic computer; Figure 4 describes the experimental arrangements for the tests of both mir-

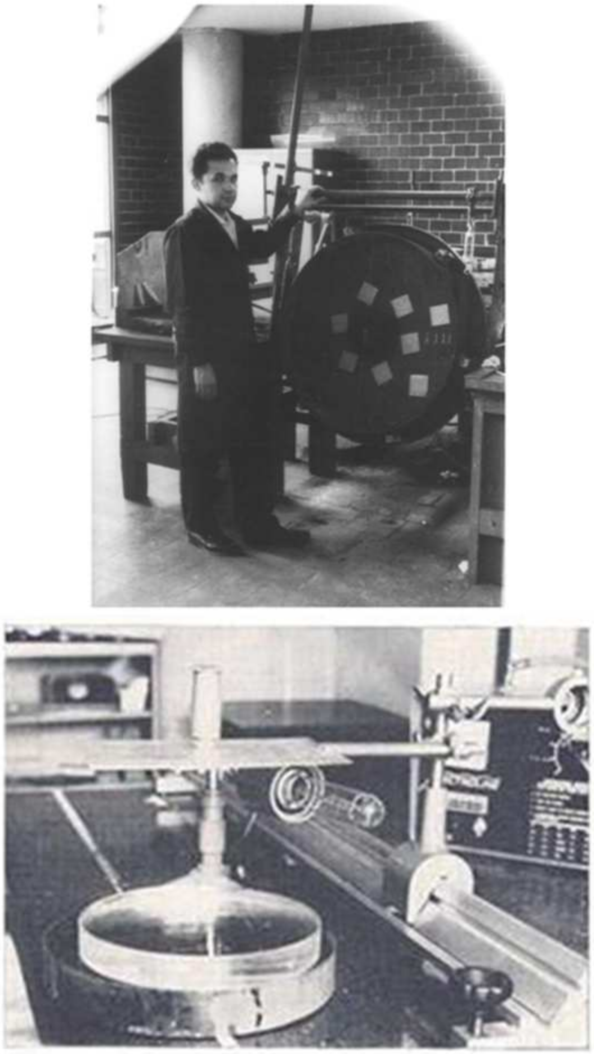

Fig. 4. Experimental arrangements for testing the primary mirror with the Ronchi test, and secondary mirror with the Newton fringes of the 84 cm Ritchey-Chrêtien telescope.

rors. At the present time, the telescope is still in operation at the Observatorio Astronómico Nacional, at San Pedro Mártir, Baja California, México (Figure 5).

4. CONSTRUCTION OF A REFLECTING TELESCOPE RITCHEY-CHRÊTIEN WITH 210 CM IN DIAMETER OF THE PRIMARY MIRROR

With the experience obtained from the construction of a telescope of 84 cm from the Instituto de Astronomía, UNAM, the first project, once the INAOE started its activities in 1972, was the construction of the optics for a new telescope with a 210 cm diam-

Fig. 5. Ritchey-Chrêtien 84 cm telescope at the Observatorio Astronómico Nacional, San Pedro Mártir, Baja California, Mexico.

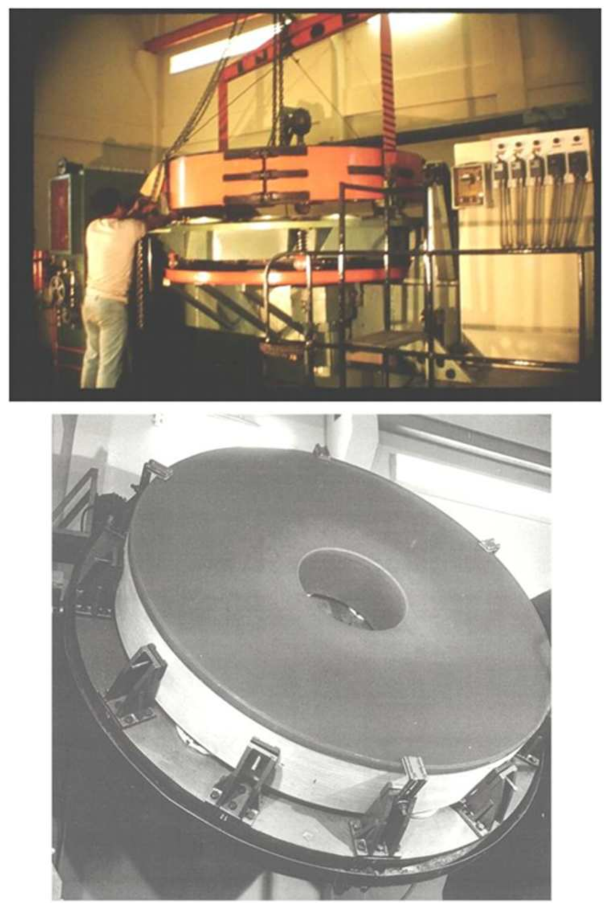

Fig. 6. Grinding and polishing machine constructed at INAOE, and the 210 cm mirror ready to be polished after the central hole was ground.

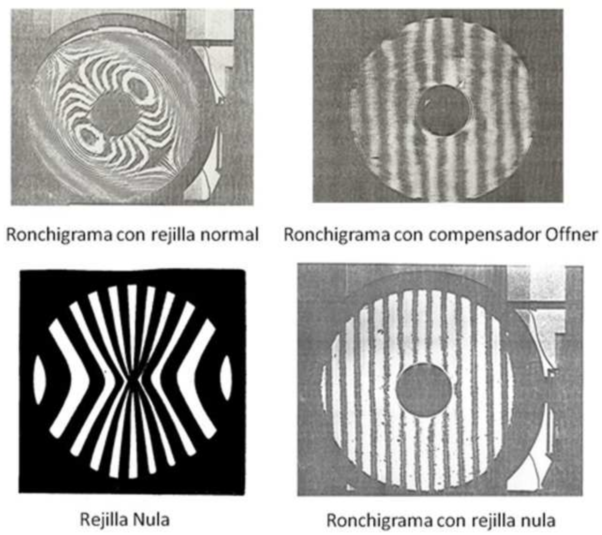

Fig. 7. Ronchi test for the 210 cm primary mirror of the INAOE telescope, using a normal Ronchi ruling, an Offner compensator, and null Ronchi ruling.

eter of the primary mirror. The design, construction, and testing of the optical components of the telescope were published in the Boletín del Instituto de Tonantzintla and in Applied Optics (Cornejo & Malacara 1974; Malacara & Cornejo 1974; Malacara, Cornejo, & Noble 1974; Noble, Malacara, & Cornejo 1974; Malacara, Cornejo, & Morales 1976; Cornejo & Malacara 1976; Cornejo & Malacara 1978). A final internal report of INAOE, contains the last information about the test of the primary mirror; where mainly the normal and null Ronchi test were applied, as well as the Hartmann method. For this last test, the Hartmann screen was constructed with the help of researchers of the Centro de Instrumentos, UNAM, and internal technical support from INAOE. Figure 6 shows the grinding and polishing machine for the 210 cm primary mirror of the INAOE telescope; Figure 7 shows the normal Ronchi test using an Offner optical compensator, and the same Ronchi test with a Null Ronchi grating (Malacara & Cornejo 1974); Figure 8 has the Hartmann screen in front of the primary mirror of the telescope in an almost vertical position, with the last experimental Hartmanngram obtained for the primary mirror; and in Figure 9 is the telescope located at the Observatorio Astronómico Guillermo Haro at Cananea, Sonora; and the team involved for the construction of the primary and secondary mirrors of the INAOE telescope. For future works in Astronomy or other fields, the $X-Y-Z$ measuring instrument, and the new polishing machine for mirrors with 8 m in diameter,

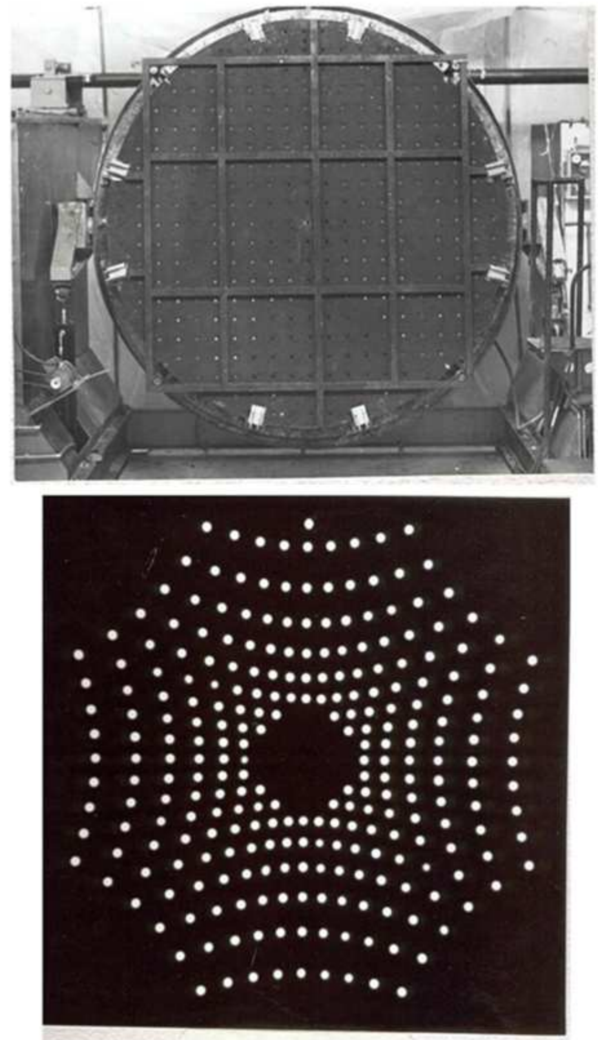

Fig. 8. Hartmann screen and last Hartmanngram showing the hyperbolic primary mirror.

located in the Aspherics Laboratory of INAOE are shown in Figure 10.

5. CONCLUSIONS

With the beginning of the first optical publications in the BOTT, the field of optics started its tradition in our country. At the present time there are more than ten institutions with optics groups doing research in several fields, and also pursuing graduate studies in INAOE (Puebla), CICESE (Baja California), CIO (Guanajuato), BUAP (Puebla), UAM-Iztapalapa (Mexico City), CCADET and Facultad de Ciencias, UNAM (Mexico City). In the case of INAOE, at the present time, the optics Department has an staff of 32 researchers; since 1973, with the be-

Fig. 9. INAOE telescope located at the Obs. Astron. G. Haro at Cananea, Sonora, Mexico; and the team for the construction of the telescope: José Castro, Alejandro Cornejo, Daniel Malacara, and Jorge Cuautle.

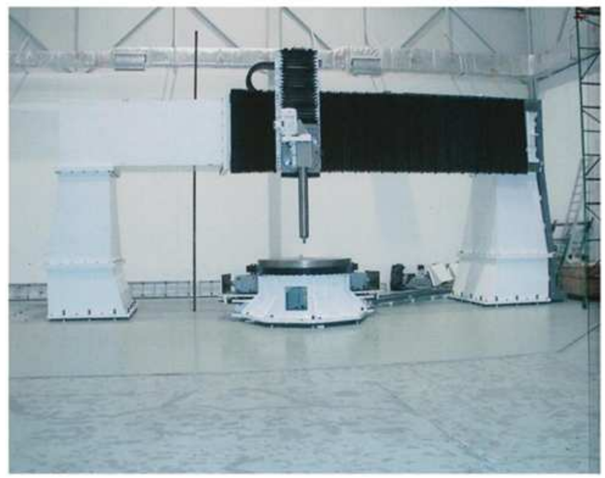

Fig. 10. Measuring XYZ instrument and polishing machine with capacity for mirrors with maximum 8 m in the diameter.

ginning of graduate studies in the field of optics, until the end of the last year, the four departments, Astrophysics, Optics, Electronics, and Computer Sciences. INAOE has granted 920 M. Sc. and 295 Ph. D. degrees. On the other hand, with the development of the first design and construction of astronomical telescopes of the Cassegrain type, with the Ritchey-Chrêtien modification; an important experience was acquired for building different type of optical components that can have diverse sizes, shapes and characteristics, either for national and international requirements. In this respect, it can be mentioned the work done at the Instituto de Astronomía, UNAM, and INAOE for the spanish telescope GRANTECAN. As an example, in Figure 11 are shown some lenses and prisms constructed at INAOE for such telescope. An important academic result of such initial works in BOTT, mainly on the subject of optical testing methods, are the paper by Malacara, Cornejo, & Murty (1975), Cornejo, Caulfield, & Friday (1981); the first just mentioned papers, was the starting point for the publication of the book "Optical Shop Testing", where D. Malacara appears as editor. After the first edition in 1972, two more editions have been published in 1992 and 2007. The book has been translated to several languages, and in 2010, was published in Japanese.

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Fig. 11. Lenses and prisms constructed at the optical shop in INAOE for the spanish telescope GRANTECAN.

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