Section 4: Current Status of Astronomy Research in Developing Countries

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Astronomy in Algeria: Past and Present Developments

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Abstract. Astronomy studies have been developed in Algeria since 1890 when the Algiers Observatory was built. Several instruments were soon installed on the site and have contributed to many scientific projects such as the international sky-map program. However, the observatory activities were suddenly interrupted by the departure of all French astronomers in 1962. Twenty years were needed before new astronomy programs were developed at Algiers observatory. They are principally based on imaging through atmospheric turbulence, solar physics and studies of pulsating variable stars. Only one observational program, however, has so far been developed. This consists of solar observations in the framework of an international program to survey the Sun's radius. The astronomers now form a relatively important team since more than twelve researchers have permanent status. This is a good start taking into account the fact that astronomy is not taught in Algerian universities. We will begin first by giving an overview of the history of Algiers Observatory, including its instrumentation. We will then present the existing Algerian team and all their current scientific work and proposed projects.

1. Introduction

Although astronomy greatly affects the daily life of Algerian people as in all Muslim countries (hours of prayer, religious celebrations etc.), the people do not know the basic explanations of current astronomical phenomena. Thus, there always are problems to define the Muslim celebration dates, which are all linked to the visibility of the lunar crescent. The celebration dates are often fixed before the conjunction between the Sun and the Moon. More astonishing was the last partial eclipse that occurred in August 11th 1999 in Algeria. In fact, the Algerian people dreaded this natural phenomenon and many of them stayed at home. These examples show clearly the state of astronomy in Algeria, a state principally due to the fact that astronomy is taught neither at school nor in the universities. Nevertheless, there are some structures in which astronomy is developed. In fact, there are several amateur clubs that cater for young people interested in this discipline. Although the clubs do not have many resources, they make considerable efforts that deserve to be mentioned. The most important

institution in which astronomy projects are developed is, however, the Algiers Observatory. This professional establishment is more than one hundred years old but Algerian society did not benefit from its learning and long experience. This paper presents, then, astronomy in Algeria focusing, however, on what has been developed at the Algiers Observatory. Thus, after a brief recall of the history of the Algiers Observatory, the present research center will be described. We will then introduce the Astronomy and Astrophysics Department and all current projects. We will make some remarks about the existing international collaboration and about the problems encountered in the full development of astronomy.

2. History of the Algiers Observatory

After several observing campaigns near Algiers during 34 years, an observatory was built on the Bouzaréah site in 1890 during the French occupation (1830 - 1962). Several instruments were soon installed that permitted intense activity at the Algiers-Bouzaréah Observatory during nearly a century. These instruments were a Foucault's telescope, a coudé refractor, a photographic astrograph and a meridian circle (lunette méridienne). The photographic astrograph was the instrument that absorbed a major part of the Observatory's activity. In fact, it was specially built and installed on the site in 1892 to contribute to the French project Carte-du-Ciel (sky map) and to the photographic catalog project. This project involved a network of several astrographs distributed all over the globe (Europe, Australia, Africa and Asia). A precise region of the sky was allotted to each observatory and continuously photographed over several years. Thus, about 5000 plates were recorded by the Algiers photographic astrograph, which operated from 1892 to 1940. Twelve minor planets were also discovered with the instrument during this period. Two of them were named El Djezair (Algeria) and Bouzaréah. The other instruments were used for many programs such as occultation of stars by the Moon, observations of planets and their satellites, of sunspots and of transits of Mercury across the solar disk etc. Another instrument, a Danjon prismatic astrolabe, was later installed on the site (1957) for astrometry programs. It was part of a network program dedicated to study the Earth's rotation and polar movements. The Algiers astrolabe has also participated in the improvement of the fundamental catalog FK4 and the elaboration of the FK5. Planets (Jupiter and its satellites, Saturn, etc.) were also observed with this instrument in order to improve their ephemerides. In the 1960s, all activities at the Algiers Observatory were interrupted by the sudden departure of the French astronomers and the lack of Algerian astronomers at that time.

3. The Present Structure of the Algiers Observatory – CRAAG.

In the early 1980s, several events permitted new astronomy developments at the Algiers Observatory. The earthquake that occurred in 1980 in the west of Algeria (about 200 km from Algiers) made the Algerian government aware of the importance of studying natural phenomena and provided the opportunity to build a new center on the Algiers Observatory site. At this time, new legislation was promulgated for the creation both of centers and of researcher status. This

gave total financial autonomy to the centers and defined permanent positions for the researchers. A new center was then created at the Algiers Observatory site which is the present Centre de Recherche en Astronomie Astrophysique et Géophysique (CRAAG). It is composed of three scientific departments. The first is devoted to astronomy and astrophysics researches while the other two are for geophysical studies. Two other departments exist also for scientific support (library, computer center etc.). When CRAAG was created, there were no astronomers. The first Algerian astronomers began to integrate the CRAAG-Algiers Observatory in the middle 1980s. By the late 1980s and early 1990s, there were about ten astronomers in the Center. They were all senior researchers, a large part of them returning from France at the end of their postgraduate studies. After a brief period of research activity in the Observatory, new events in Algeria caused the departure of the half of the total number of the astronomers. It was necessary to replace those who left. The lack of astronomy teaching in the Algerian universities forced the astronomers remaining to develop their own educational program. Thus, many students coming from various physics disciplines continued their postgraduate education by participating in the existing research topics. The group is now composed of 14 astronomers, all having permanent positions. They are part of different research teams working in the two laboratories of the department: (i) the stellar and astrometry laboratory and (ii) the astrophysics laboratory. The projects developed in the laboratories are presented in the following sections.

4. The Stellar and Astrometry Laboratory

Two research teams compose this laboratory. The first one develops studies related to solar astrometry and imaging through atmospheric turbulence while the second one to the stellar instabilities.

4.1. Solar astrometry and atmospheric optics (Dr. A. Irbah)

A small group composed of seven astronomers is involved in these research programs, which are concerned with the variations observed in measurements of the solar diameter and with the effects of atmospheric turbulence on the recorded data. In fact, diameter measurements made with an astrolabe at Calern Observatory (France) during more than two solar cycles show apparent variations. The observed variations are in opposite phase to the solar cycle, defined by the sunspot number. These results have given rise to many scientific works and experimental developments. Thus, several astrolabes in the world were specially adapted for solar observations. The future space mission *Picard* will also be dedicated to this topic. It will consist of the launch in 2002, of a microsatellite equipped with several solar experiments; one devoted to solar-diameter measurements. This scientific context led to initiation of a solar-radius observation program at Algiers Observatory. An experiment similar to the one at Calern Observatory is now developed for the Algiers astrolabe. This program will be installed in the south of Algeria at the geophysical observatory of Tamanrasset, which is part of CRAAG. Part of this program will be to observe, together with all solar astrolabes around the world, the space mission *Picard* and also to observe in coordination with the new solar observing program at

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Calern Observatory (DORAYSOL and PICARDSOL). DORAYSOL (Definition and Observation of the Sun's Radius) is the new version of the solar astrolabe while PICARDSOL is the ground-based counterpart of the space mission. In the framework of this program, the effects of atmospheric turbulence on the measurements are studied. They are developed in order to quantify the errors in diameter measurements with the observing conditions. These are defined by the Fried's parameter, the atmosphere time constant (s), the isoplanatism patch size and the spatial coherence outer scale of the wave-front. Numerical simulations are used to generate random perturbed atmospheric wave-fronts. Solar images as recorded in the program are then simulated in various observing conditions and used to define the behaviour of errors in the diameter measurement. The results deduced from this work led to the development the seeing monitor MISOLFA (French-Algerian Solar Imaging Monitor), which will observe at the same times as the solar observations made at Calern Observatory (DORAYSOL and PICARDSOL) and by the satellite *Picard*. With the Tamanrasset program, observing conditions will be directly deduced from solar-image sequences used for diameter measurement. The third research topic concerns the analysis of visual solar data recorded at Calern Observatory during more than two solar cycles. Special signal-processing methods are needed since diameter measurements are non-uniformly sampled and present some temporal gaps. The methods developed show new periodicities previously undetected, such as the 27-day rotational period, which appears to be close to the Carrington rotation. All these results, which require further study, are currently being developed by the research team. For more details, some references related to all this work are given at the end of the paper (Irbah et al. 1999, Laclare et al. 1996, Lakhal et al. 1999, Moussaoui et al. 2000).

4.2. Stellar instability project (Dr H. Sadsaoud)

The main objective of the stellar group is to develop an automatic photometric observing station in Algeria, and to create an Algerian research team to run and to use it. The observing set-up will enable our researchers to learn the modern techniques of stellar observation and the latest techniques in image and signal processing. The research themes are principally stellar physics and particularly stellar pulsations of hot stars, with the aim of understanding their instability mechanism, functioning and evolution, a subject which the astronomy team of the Bouzaréah Observatory has been working on for several years now. Members of the team have good experience in this observational domain since they often observe abroad using big telescopes equipped with high-performance systems of data acquisition (high-resolution spectrographs). These fields of research need a theoretical and observational study of variable stars and notably the instability they represent. The cause of these stellar instabilities has become more apparent these last two years, thanks to the publication of more precise opacity tables than those previously used. Scientific work reveals that the destabilizing mechanism of these stars is similar to the κ-mechanism operating in the Cepheid instability band. It is, then, with the aim of studying stars in general, and in particular the B-type variable stars, that we are envisaging the installation of the first observing station in Algeria, which would permit us to follow the photometric and spectroscopic evolution of the B-type stars. The station would be installed

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first in the north, thanks to the help of Algiers Observatory. The final transfer to a much better site would be envisaged after the results of the site survey in Algeria, which is in progress. In recent years, instrumental evolution permits the realization of good observations. Yet, determination of the pulsation parameters by classical methods is not yet on a level of with new data of high quality. By their relative inaccuracy and difficulty of use, these methods are not adapted to interpret all the information held in the high-resolution spectroscopic profiles which are now being obtained. A new method, the moment method, seems very promising because it makes use of the whole observed profile, however, important work is to be done, particularly taking into consideration the Coriolis force or thermal effects. Despite its strength, this new way of analysis rests upon a restricted theoretical basis: the adiabatic linear case, which must be adapted to a high-amplitude case. In fact, the study of the influence of non-linear effects on the pulsations, with the help of an imaging-method development, is thus to be envisaged as an area of an international collaboration.

5. The Astrophysics Laboratory: Solar-Terrestrial Project (Dr T. Abdelatif)

In the Astrophysics Laboratory there is a small group of researchers interested mainly in solar-terrestrial interaction. A few aspects of this very vast domain have been selected for two reasons: (i) the human component is very small and very few astrophysicists have been educated in Algerian universities, (ii) the studies have to be of national interest (e.g. telecommunications). The final goal is to constitute a team of researchers that are able to study most of the solar phenomena that affect the Earth's electromagnetic environment. The first project concerns the study of the propagation properties of the ionosphere. A computer code has been developed in order to simulate the propagation of an electromagnetic pulse through an inhomogeneous plasma. We hope that we will be able to study with this code any observational model of the ionosphere. CRAAG has recently acquired several dual-frequency GPS receivers; we are planning to use the collected ionospheric data to establish a model of the local ionosphere for solar-quiet days. It will then be possible to follow up ionospheric perturbations due to solar events. A theoretical model as well as a computer code will be needed to invert the time-dependent data in order to produce a time-dependent three-dimensional model of the ionosphere. The second study, we are involved in, concerns the effect of sunspots on the total solar irradiance. The total solar irradiance of the Sun is modulated by the solar activity and especially by the sunspots on the surface of the Sun. This irradiance will be computed using the available data of sunspots area versus time and latitude. The computed irradiance will be compared with the measured one using the ACRIM data (also available). An optimization of the fit will be used in order to constrain some of the free parameters like the limb-darkening function, distribution of the blocked energy etc. The third study is related to the study of the solar cycle. The forecasting of solar maximum or minimum is very important for all satellite and telecommunication activities. The study of past solar activity can be a valuable asset for forecasting. The distribution of maxima and minima will be deduced from the raw data using a new technique. Information concerning features of

the solar cycle (periodicity, minima and maxima, rate of variation) is extracted using decomposition in terms of Tchebychev polynomials. This new method has the advantage of computing statistical quantities by using a variable window over the data. An ongoing study concerns the propagation of acoustic waves in an atmosphere embedded in a magnetic field, this study has been the subject of many publications in the past. The actual ongoing research concerns the absorption of p-modes by sunspots. The future development of the laboratory concerns the observational aspect; it is intended to acquire a small station for solar observations that will produce daily pictures of the Sun and its activity in different wavelengths. It is clear from the above that our main interest is the Sun, its activity on different time-scales and its effects on the geosphere.

6. International Collaboration

We have much international collaboration with several foreign institutions in various countries (France, Spain and England). These collaborations have been set up in order to help the Department in the development of all the projects. The most important one is, however, the French scientific cooperation that exists up to now. It was initiated in the middle 1980s to reactivate astronomy at Algiers Observatory. Since then, three cooperation programs (CMEP) for astronomy developments at CRAAG-Algiers Observatory have been set up with the French Foreign-Affairs Ministry. There are also annual cooperation programs with the French CNRS. Thus, this collaboration permitted the obtaining of support from French astronomers and also provided useful funds for visiting their laboratories and acquiring some equipment. It also permits young Algerian astronomers to complete their own education. The principal French partners are the Observatoire de la Côte d'Azur and the UMR Astrophysique of the Nice-Sophia-Antipolis University.

7. Difficulties Encountered in the Development of Astronomy in Algeria – Conclusion

Astronomy has existed in Algeria for more than a century. The major activities in this discipline were developed at the Algiers Observatory, which was built in 1890. At this period, several instruments were installed on the site, allowing the Observatory to make considerable contributions to the international astronomical community. However, these intense activities suddenly stopped in the beginning of the 1960s, because of the departure of French astronomers in 1962 and the lack, at that time, of Algerian astronomers to carry on the activities. This situation persisted until the creation of the present CRAAG, twenty years later. It was at this period that the first Algerian astronomers begun to integrate the centre, returning from foreign universities at the end of their postgraduate studies. Several astronomy projects were then initiated and are still developed up to now. However, they encountered many difficulties to develop new astronomy in Algeria. The most important was the very limited funds allotted to the discipline. The consequences for the present astronomers have been difficulties in arranging regular exchanges with foreign laboratories, in acquiring new instrumentation and recent documentation, and in correctly responding to

the astronomical needs of Algerian society. Although the astronomer group of the Algiers Observatory is now relatively large, it remains insufficient to allow a full development in all areas of astronomy, taking into account that astronomy is taught neither at school nor in the universities. To avoid these difficulties, the Algerian astronomers set up international collaborations in order to develop research in astronomy. Thus, new efforts will be made in order to pursue the existing projects but also to initiate, in the next few years, new ones in stellar and solar physics principally, in helioseismology and asteroseismology, instrumentation, cosmology etc. This will necessitate however, a noticeable increase in the number of Algerian astronomers and thus the setting up of a better educational program. If the participation of young Algerian astronomers in international schools is very helpful, it still remains insufficient. Introduction of basic programs in schools and the setting up of annual summer universities on specialised topics seem to be the best way for a rapid full development of astronomy in Algeria. International aid for giving shape to this program will be a valauble contribution.

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Discussion

Wang expressed interest in the studies of atmospheric optics. Have they been published? Irbah replied that some references to the work are given in the paper. The major part of the studies of atmospheric optics are concerned with the effects of atmospheric turbulence on mesasurements of the solar diameter. The studies are developed by numerical simualtions and observational data. Similar work at the Calern Observatory in France will be transferred to the Tamanrasset Observatory in southern Algeria, as part of an international

project. We are, however still developing a seeing monitor to rest several sites in Algeria.

Fierro said that México also has an old Carte-du-Ciel instrument. They completed their part of the project and now find the telescope wonderful for educational purposes. Irbah replied that he had not known that México Observatory had been part of the Carte-du-Ciel project, but he agreed about the educational potential of the instrument. It was also still useful for research programmes because of the large stock of plates obtained over a period of about fifty years.

Chamcham remarked that, between Morocco and Algeria there could be uncertainty of up to two days in the visibility of the lunar crescent and astronomers in Morocco hesitated to announce observations of the crescent –are there similar problems in Algeria? Irbah replied that, if the crescent csn be observed in Algeria then all coutries to the west, including Morocco, should also be able to observe it. On the other hand, a crescent seen in Morocco might have been missed in Algeria. The visibility dates between the two countries should not, however, differ by more than a day. In Algeria they make calculations of the visibility and give them to the authorities, who make the necessary decisions. During the last few years, Algerian and Moroccan calculations have been in good agreement, but the dates of celebrations in the two countries have differed.