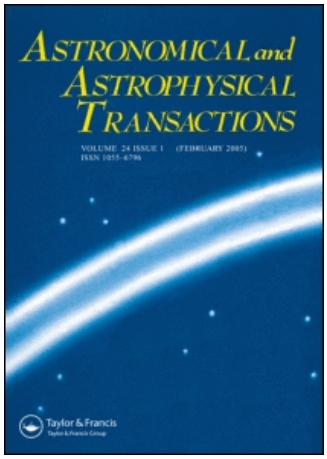

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COOPERATION OF THE SCIENTISTS OF UKRAINE AND TURKMENISTAN IN INTERNATIONAL PROGRAMMES

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Cooperation of the scientists of Ukraine and Turkmenistan for more than 30 years continues in different fields of astronomy and, recently, in meteorology.

We work jointly at the Mount Dushak-Erekdag Observatory which is located in 45 km from the capital of Turkmenistan, Ashgabat. This southernmost observatory of the former Soviet Union has one of the best sky views in central Asia. Its location is favourable for measuring the 'longitude gap' in the asteroseismological networks formed. The 0.8 m telescope of the Astronomical Observatory, Odessa National University, which is installed there participates traditionally in international programmes and multisite campaigns for observations of variable stars, satellites of large planet, comets, asteroids, etc. The infrastructure developed at the site, the stable economy and the friendly atmosphere in Turkmenistan make the Mount Dushak-Erekdag Observatory very promising for ground-based astronomy.

From the late 1970s the Odessa Observatory has operated under a treaty about cooperation and mutual assistance with Turkmenian institutions. That is very important now for the work under the complex political and economical situation in our countries.

Keywords: History of astronomy; Asteroseismology; Site testing; Telescopes; Instrumentation

1 HISTORICAL INTRODUCTION

The first telescope of the Odessa Astronomical Observatory in Turkmenistan was installed in the 1970s. It was used for spectral observations of different types of stars for spectral catalogues. Scientific researchers from Odessa went in expeditions to the Turkmenian Observatory in Vannovsky for 2–3 months. Turkmenian colleagues visited Odessa often to undertake cooperative investigations of comets and meteors, to exchange experiences, and to advance the professional community. Since that time we have noticed the advantageous characteristic of the climate of the central Asian mountain plus desert, which has a high

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and very stable atmospheric transparency for long periods, especially in the summer–autumn period.

20 km from Vannovsky Observatory is located Mount Dushak-Erekdag (altitude, 2650 m). When astronomers of the Soviet Union investigated the sites with the best sky view for the installation of large telescopes, this mountain was in the programme of investigations. It was ascertained that the astronomical climate the Mount Dushak-Erekdag is comparable with the climate of such well-known sites as Majdanak in Uzbekistan or Sanglok in Tadzhikistan (see for example Ovezgel'dyev *et al.* (1984)).

2 MOUNT DUSHAK-EREKDAG OBSERVATORY

Upto the early 1990s the modern observatory had been built on the southwestern slope of Mount Dushak-Erekdag at an altitude of 2020 m. The advantages of the site are as follows: over 200 usable nights per year, a high and stable sky transparency and a low light pollution in spite of the fact that it is in the vicinity of the capital of Turkmenistan. More detailed data of local climate, weather statistics, extinction, etc., have been presented by Dorokhov *et al.* (1995).

Odessa Astronomical Observatory constructed and installed two telescopes of 1 m and 65 cm for the new Turkmenian Observatory. Turkmenian astronomers still use both telescopes.

The 80 cm telescope of the Odessa Astronomical Observatory was installed there in 1991 (Dorokhov *et al.*, 1995). Mount Dushak-Erekdag Observatory is situated in 3000 km from Odessa but it was common for many astronomical institutions to have their own networks of small mountain observational stations during the time of the former Soviet Union. The Astronomical Observatory of Odessa State University also had its own telescopes at Peak Terscol (North Caucasus) and The Bezimyannij Pass (Armenia). However, the wonderful features of the central Asian sky were especially attractive for modern astronomical research.

After the disintegration of the Soviet Union, great difficulties arose for prolonging the work at the remote observatory. The Odessa Observatory lost financial support for scientific research, and particularly for expeditions.

Further the main work of the telescope became participation in international programmes and asteroseismological campaigns because of financial difficulties. Such observations are paid for partially or completely by the institutions requesting them.

3 INTERNATIONAL PROGRAMS

In 1995 we took part in the Russian Ministry of Science programme 'monitoring of unique astrophysical objects'. Investigations of X-ray pulsars, black-hole candidates, cataclysmic variables, etc., were carried out by the network of observatories of the Commonwealth of Independent States. It was an absolutely new field for our experience. The most important result for us was the detection of the transient optical flashes of Be–X-ray binary A0535+26 (Dorokhov and Dorokhova, 1998). Unfortunately this programme is no longer financed and was therefore interrupted. However, when we have an opportunity, we continue observations of some of these very interesting objects.

In 1997 we jointly participated in a cooperative programme which was prepared and organized by N.V. Emelianov (Sternberg Astronomical Institute, Russia). The orbits of the satellites were determined with an intrinsic accuracy of 25 km (0.01) (Emelianov *et al.*, 2000).

From 1992 we actively took part in international programmes of observations of asteroids and comets (see for example Spencer *et al.*, (1995)), frequently using the assistance of Turkmenian specialists for the investigations of comets, meteors and meteorites (see for example Mukhamednazarov (1999)). In turn, we assisted Turkmenian astronomers with their investigations. Sets of multicolour photometric data of comet Hale–Bopp and trial observations of artificial Earth satellites were obtained using our photometer.

4 MULTISITE CAMPAIGNS AND OWN INVESTIGATIONS

In 1992, a year after the telescope's installation, we first participated in the asteroseismological multisite campaign. The target was the well-known rapidly oscillating Ap (roAp) γ Equ. There were some discussions before the campaign about whether it is a variable or a constant star. After the campaign, four periods of about 12 min with extremely low amplitudes (less than 0.8 mmag) were obtained unambiguously. Some well-known observatories worked for the campaign, such as the European Southern Observatory, the South African Observatory and the Lowell Observatory. The data quality obtained by our continuous photometry was comparable with their data quality (Martinez *et al.*, 1996). The noise level was less than 0.4 mmag. This first success encouraged us to continue to work in these campaigns.

Our observations in the multisite campaigns are important because of the existence of the so-called 'Asian gape', that is substantial lack of coverage at Asian longitudes in observations of asteroseismological networks (Dorokhova *et al.*, 2000). The location of Mount Dushak-Erekdag Observatory (latitude, $+38^\circ$ N; longitude, 4° E) proves to be suitable for the completing such 'gaps', for example between European and Chinese observatories.

During l992–2001 the Odessa 0.8 m telescope took part in nine multisite photometric campaigns of well-known networks: Stellar Photometry International (STEPHI), Delta Scuti Network (DSN) and mini-Whole Earth Telescope (mini-WET) (see also Dorokhov *et al.*, (1998)).

The campaigns provide experience of working at an advanced level of scientific investigations and present an opportunity to take part in projects with leading specialists. However, it demands permanent readiness of equipment and high accuracy of observations. We permanently have to modify and improve the instrumentation and have the benefit of comparing and controlling our equipment with the best equipment in the world.

A very short time remains for an own research under such programmes, only the intervals between the observations of target stars. Nevertheless we try to continue the search for and investigation of low-amplitudes rapidly pulsating (roAp, δ Scuti, λ Bootis, etc.) stars and close binary systems. As a result a series of λ Bootis stars were investigated (see for example Dorokhova and Dorokhov (1996)) and a roAp star HD99563 was discovered in the survey of roAp stars (Dorokhova and Dorokhov, 1998). It was the second case in the world of a discovery of a roAp star in a northern hemisphere observatory (Handler and Paunzen, 1999).

5 CLIMATE RESEARCH

Since Turkmenistan participates in the Climate Change – Kyoto Protocol and other agreements concerning climate, atmospheric ecology and weather forecasting, investigations of the atmosphere become very important. Turkmenian and Ukrainian scientists started a series of photometric research studies on the behaviour of atmospheric transparency at different wavelengths. It is important to connect these data with detailed and various solar data

and parameters. We try to inform each other about all new results in this area. These investigations at the interfaces between astronomy, atmospheric physics and hydrometeorology reciprocally enrich science in both countries.

6 IMPROVING INSTRUMENTATION

For the observations, 11 prolonged (2–4 months) expeditions were realized from Odessa to the mountain observatory in Turkmenistan.

The observations from Mount Dushak-Erekdag Observatory were performed with a dual-channel photomultiplier tube photometer (Dorokhov and Dorokhova, 1994). Every year we tried to improve the interface and software of the photometer using modern electronic advances.

One example of progress is the internal calibration system in the dual-channel photometer (Dorokhov, 1999). This makes it possible to correct the channels' drift in 2–3 min with an accuracy of better than 0.02%. Usually this procedure was longer by three to four times and involved rather large errors.

Now we are constructing a device for automatic movement of the telescope for a three-star programme (Breger and Handler, 1993). The cycle of observations Sky – Comparison 1 – Variable – Comparison 2 – Sky can be fulfilled in 5 min and is automatically managed by a computer.

The basics of these improvements are usually prepared in the laboratories and workshops of Odessa Observatory but the assistance of the Turkmenian scientists and engineers sometimes was needed for successful installation of new equipment. This assistance was especially important in urgent cases which demanded a fast response, ingenuity and quick wit at the isolated mountain observatory.

7 CONCLUSIONS

We would like to mention the benefits of Mount Dushak-Erekdag Observatory. It had been built with the suggestion that it would be a large institution with time. There are now two empty domes at the Observatory where 1 m and 2 m telescopes can be installed. Some buildings for office and service and a dormitory suburb for the staff had been prepared, too. The site has a vast open horizon and much space for the installation of new modern telescopes.

The southern location of the Observatory is suitable for observations of southern stars to δ equal to -40° and cooperation with observatories of the southern hemisphere.

The next feature is the location of the site which is in the vicinity of Ashgabat. The capital's infrastructure provides the opportunity to utilize the airport, good roads, communications, etc. At the same time, Ashgabat is not a large city (400 000 inhabitants) and illuminates the sky only slightly in the east, being situated behind the mountains.

It is also important that Turkmenistan has wealthy natural resources and a stable and expanding economy. Because of these advantages, one can assume that further development of Mount Dushak-Erekdag Observatory can be realized with careful financial support and does not require great investment.

The experience of cooperation for more than 10 years under the independence of Ukraine and Turkmenistan has shown that it is fruitful for the science of both countries and the world community.

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