STEPHANION OBSERVATORY. GREEK–UKRANIAN ASTROLINK

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The Astronomical research developed during the 35 years of action of the Stephanion Observatory is reviewed in this report. During these years scientists from all the Astronomical Institutes of Greece as well as from many other countries conduct astronomical research programs realized in the Stephanion Observatory. The research on the red dwarfs is a dominant part of the scientific work done. The international cooperation of the Greek scientific teams was developed in the frame of this research. The Greek – Ukrainian scientific cooperation during the last decade in the frame of broader international cooperation as well as the bilateral ones were very prosperous and set the basis of a promising scientific cooperation in the future in the field of Astronomy.

INTRODUCTION

The moment of the twilight of a new century and, far much more, of a new millennium is a moment of the account for the achievements and the failures of the past, of the self potential resume and of the perspectives for the entire World, the particular Countries, the Institutes, the individuals and for the Scientific community as well. There is a specific reason that we refer ourselves to the Stephanion Observatory of Greece in a conference for the perspectives of the Ukrainian Astronomy in the new century. A tight scientific cooperation with scientists from the former eastern countries and from Ukraine as well was the started point for astronomers from the Stephanion Observatory working in the field of the variable stars. The best way to present this prosperous scientific cooperation is to refer ourselves to the research programs which has been developed at the Stephanion Observatory. In the following, after a brief presentation of the Stephanion Observatory a brief review of the research at the Stephanion Observatory will be presented. The long lasting prosperous scientific cooperation constitutes foundations of the best perspective for future scientific cooperation between Greek and Ukrainian astronomers.

THE STEPHANION OBSERVATORY

In spite of the famous blue Greek sky, Greece did not have, until the beginning of the 1960s, an observatory properly equipped for modern astrophysical observations. Two Balkan wars at the begining of the century, the social and economic integration of two million war refugees in 1922, two world wars and one civil war, leave no room for investments in basic research. Greek astronomers working in the field of modern astrophysics were inforced to work abroad. Nevertheless, in the 50s the Greek National Committee for Astronomy, under the Chairmanship of the late Professor Xanthakis, started a preparatory work for the selection of sites which could be suitable for the foundation of an astrophysical observatory, but no progress could be made because of the lack of the necessary funds. Among the best observational sites, the Stephanion of Corinth in Pelopones ($\delta = 22°49'44'', \alpha = 37°45'15''$) located at an altitude of 800 m was proposed. In 1966 the NATO Science Committee awarded a research grant to L. N. Mavridis and H. Neckel to install a 38-cm reflector (f/21) in Greece. This reflector has been belonged to the Hamburg Observatory and been involved in the variable star photoelectric observations program. Taking into account the Academy's research and the experience of a visit of a group of eminent astronomers in 1964, Mavridis and Neckel decided to install the 38-cm reflector in the outskirts of Stephanion. The photoelectric observations started in March 1967 and continued until September 1970, when the NATO project was terminated and the telescope was transported back to Hamburg. The following observations were carried out at the Stephanion Observatory with the Hamburg reflector: 1. Photoelectric observations of M-type stars in the B, V colours of the international U, B, V system by H. Neckel [26]. 2. Photoelectric observations of galactic cepheids in the U, B, V colours of the international U, B, V system by the team of the Aristotle University of Thessaloniki [4]. Meanwhile, the European scientific community had become aware of the great advantages of the site of the Stephanion Observatory. In October 1966 a satellite observing station belonging to CNES was installed in the grounds of the Stephanion Observatory. It included one Doppler tracking and one Laser ranging station. The station was in regular operation until the end of August 1967, when it was transferred to France [16]. In 1964, the 40-cm van Straaten Cassegrain reflector belonging to the Utrecht Observatory was installed in the grounds of the Stephanion Observatory. The operation of this telescope, which was used by the astronomers of all the astronomical institutes of the Netherlands, started in July 1967. The project which was known as the "Netherlands European Southern Observing Station" was terminated in the fall of 1973 and the telescope was transported again back to Utrecht [27]. In June 1971 a 30-inch Cassegrain reflector with asymmetric mount (focal ratio f/3 for the primary hyperbolic mirror and f/13.5 for the Cassegrain focus) constructed by the U. S. firm Astro Mechanics was installed in the grounds of the Stephanion Observatory. The new telescope was equipped with the following auxiliary equipment: (1) one Johnson dual channel photoelectric photometer with offset guider unit, constructed by Astro Mechanics, which is cooled with dry ice and is suitable for carrying out photoelectric observations in the U, B, V, R, I colours of the international U, B, V system and (2) one Meinel plane grating spectrograph with flat-field folded Schmidt camera f/2 focal ratio constructed also by Astro Mechanics. This telescope, which belongs to the Department of Geodetic Astronomy, Aristotle University of Thessaloniki and is of the light-collector type, turned out to be very suitable for the photoelectric observations of variable stars. The observations with the new telescope started in July 1971 and continue regularly until now. At that time it was the biggest telescope in the Balkan area.

SOME OF THE MAIN RESULTS OBTAINED WITH THE 30-inch REFLECTOR OF THE STEPHANION OBSERVATORY

The 30-inch reflector has been used since 1971 by the astronomers of the Aristotle University of Thessaloniki, the Democritus University of Thrace, the University of Ioannina and numerous astronomical institutions outside Greece for carrying out the photoelectric observations of variable stars. Three main types of variable stars are under investigation, namely: a) the flare stars of the solar neighborhood, b) the variables of the RS CVn type and c) the galactic cepheids. In the following the main research programs referring to the flare stars of the solar neighborhood and the RS CVn stars will be summarized [20]:

Monitoring of the Flare Activity and the Quiet-state Luminosity of Flare Stars

One of the main programs carried out with the 30-inch Cassegrain reflector is a systematic monitoring of the luminosity of selected flare stars of the solar neighborhood. This monitoring is being carried out mainly in the B color of the international U, B, V system. During most of the observing nights, however, additional observations are being made in the U, B, V colors of the same system. These observations allow us to study the behavior of the colors of the stars under investigation. The following flare stars of the solar neighborhood have been observed so far: EV Lac, BY Dra, AD Leo, UV Cet, YZ CMi, DT Vir, DO Cep, BD +160 2708, BD +550 1823 and Gl 182. The first result of these observations is the detection of stellar flares and the determination of the corresponding light curves. In this way many hundreds of flares of the stars under investigation could be detected and studied so far. In addition, to the flare patrol, it has been possible, through a proper arrangement of the observational procedure, to use the same observations for the determination of the quiet-state luminosity of the stars under observation during the monitoring period. The quiet-state luminosity being determined in such a manner refers to the B color or to the U, B, V colors of the international U, B, V system, depending on whether the monitoring is being carried out in the B or in the U, B, V colours. In this way very rich observational material concerning the flare activity and the quiet- state luminosity of the flare stars under investigation could be obtained so far [21]. This material is of special value for three reasons: (1) it covers a fairly long period of time (1971 until now), (2) it is of a high accuracy, and (3) it is homogeneous enough, because it has been obtained by the same team of observers, using the same methods for the execution and reduction of the observations and the same instruments. With the help of this observational material a number of investigations concerning the phenomenon of the flare activity could be carried out. In the following some of the main results of these investigations are being summarized.

Long- and Short-term Variations of the Flare Activity and the Quiet-state Luminosity

A great percentage of the observational material obtained at the Stephanion Observatory refers to EV Lac flare star. This star shows the well known BY Dra syndrome, *i.e.*, a short-term variation of the quiet-state luminosity with the period of 4.375 days and the amplitude $\Delta V = 0.08$ mag. This variation is being interpreted by most of the authors as indicating the existence of starspot(s) on the surface of the star, which are rotating with the same period. Evidence for rotational light modulation by transient starspot formation was found by analyzing the quiet state luminosity variations together with the flare frequency distribution over the phase for EV Lac, BY Dra and DO Cep flare stars [6, 7, 8]. With the help of the observational material obtained at the Stephanion Observatory it could be shown that, besides this short term variation of the quiet state luminosity, there is also a long-term fluctuation of the mean annual values B of the quiet-state luminosity of the star with the amplitude of about 0.3 mag and a period of about 5 years. Similar fluctuations show also the mean annual values of the flare frequency P(1) and the integrated flare intensity P(2) of the star. Moreover, very strong negative correlations exist between the values of B corresponding to a given year and the values of P(1) and P(2) corresponding to the previous year, in the sense that years with the enhanced flare activity are followed by years with the lower quiet-state luminosity [22]. This and other similar results could be interpreted as indicating that years with the enhanced flare activity are followed by years with the larger starspot coverage on the stellar surface. This conclusion, being confirmed by additional observations, could be of importance for a better understanding of the physical processes underlying the phenomenon of stellar activity [23].

Very Short-term Variations of the Quiet-state Luminosity

The existence of another type of variations of the quiet-state luminosity of EV Lac star the very short-term variations was established with the help of the observational material obtained at the Stephanion Observatory [25]. In fact, during most of the nights the luminosity of the star remains constant (standard deviation is less than 0.04 mag during 2 hours or more). In some other nights the luminosity of the star shows a fairly sinusoidal variation with a period between 0.5 and 2.0 hours and an amplitude between 0.1 and 0.2 mag. In some other nights, on the contrary, the stars luminosity shows very irregular variations with a duration of at least few hours and an amplitude of about 0.4 mag or even more.

Dependence of the Flare Activity on the Phase of the Short-term Periodic Light Variation of BY Dra

BY Dra is another flare star, besides EV Lac, for which numerous observations were carried out at the Stephanion Observatory. This observational material, together with additional material obtained at the Byurakan, Konkoly and Matra Observatories were used for a systematic study of the flare activity of this star during the period 1971–92 [24]. The following conclusions could be drawn: a) the flare activity of BY Dra shows also a long-term fluctuation with a very pronounced maximum during the years 1973–75 and a new enhancement of the activity from 1987 onwards, b) there is a clear tendency for the flares of BY Dra to appear during certain part of the period of the short-term periodic light variation of the star (P = 3.8285 days). This could be interpreted as indicating a pronounced tendency of the flares on BY Dra to be originated within the part of the stellar surface covered by the magnetic field (B = 2.800 Gauss, f = 60%).

Co-ordinated Simultaneous Multiwavelength Observations of Flare Stars

It is obviously that the physical processes connected with the phenomenon of flare activity, and more generally of stellar activity, would be better studied, if we could have at our disposal simultaneous observations of these stars in various spectral regions. For these reasons an effort is being made in recent years to organize co-ordinated multiwavelength observations of selected flare stars. In these campaigns, besides the optical observations, an effort is being made in order to secure also simultaneous observations in as many other spectral regions as possible, such as the X-rays and the ultraviolet spectral regions with the help of artificial Earth satellites, the region of radiowaves with the help of radio telescopes, *etc.* Because of the fairly great number of clear nights the Stephanion Observatory is a very welcome partner in most of these campaigns. In the following some of the programs of co-ordinated simultaneous multiwavelength observations of flare stars in which the Stephanion Observatory has been actively involved will be summarized:

1. Simultaneous optical and radio observations of UV Cet flare star in October 1972. In the framework of this joint program between the Stephanion Observatory and the Jodrell Bank Radioastronomy Observatory in the United Kingdom a very large flare was observed on October 11, 1972 on UV Cet flare star both in the optical region at the Stephanion Observatory (Δm greater than 4.5 mag) and in the radiowaves (408 MHz) at the Jodrell Bank. The maximum of the optical flare precedes that of the radio flux by approximately 8 minutes. These results have been of fundamental importance for a better understanding of the mechanism of the origin of radio flares [17].

2. Simultaneous optical, radio and X-ray (EXOSAT) observations of BY Dra flare star in September 1984 [9].

3. Simultaneous optical, radio and X-ray (EXOSAT) observations of UV Cet flare star in December 1985 [10].

4. Simultaneous optical, ultraviolet (IUE), and microwave (VLA) observations of Gl 182 flare star in October 1983 [18].

5. Co-operative optical and radio observations of EV Lac flare star in August 1990 [15].
6. Co-ordinated optical observations of EV Lac flare star in September 1991 [3].
7. Co-ordinated optical and radio observations of EV Lac flare star in September 1992 [1].
8. Co-ordinated observations of the red dwarf EV Lac flare star in 1993 [2].
9. Co-ordinated Multiwavelength Simultaneous high resolution photometry for observing rapid optical oscillation on red dwarfs. [28].

Co-ordinated Simultaneous Multiwavelength Observations of RS CVn Stars

The RS CVn stars are generally G- and K-type sub-giants in close binaries. They rotate with periods of, typically, a few days. At least one of the components of the system shows evidence of spots and other phenomena associated with flare activity. Until recently the flares on the RS CVn stars were detected mainly in the microwave region and less frequently in the ultraviolet and X-ray regions, while optical continuum flares were considered to be extremely rare. Observations of the RS CVn star II Peg carried out at the Stephanion Observatory in August 1989 and July-September 1990 tend to dispel that idea [19]. A number of co-ordinated simultaneous multiwavelength observations of RS CVn stars have been organized in recent years. The Stephanion Observatory participated actively again in some of these campaigns, such as the followings:

1. Simultaneous optical, ultraviolet (IUE), X-ray (GINGA) and radio (VLA) observations of RS CVn star II Peg in August 1989 [11].
2. Simultaneous optical and ultraviolet (IUE) observations of RS CVn star HR 1099 in December 1989 [14].
3. Simultaneous optical and ultraviolet (IUE) observations of RS CVn star II Peg in July/September 1990 [12].
4. Simultaneous optical observations of RS CVn star II Peg in August 1991 [5].
5. Simultaneous optical and ultraviolet (IUE) observations of RS CVn star SZ Psc in September 1991 [13].

CONCLUDING REMARKS

From the discussion above it becomes evidently that fairly important observational research programs in the field of stellar activity (flare stars, RS CVn stars) have been carried out so far at the Stephanion Observatory. These activities make the Stephanion Observatory one of the leading astrophysical observatories all over the world in the field of stellar activity. Furthermore, the research activities carried out at the Stephanion Observatory have contributed very considerably to the development of Optical Observational Astronomy in Greece, as manifested by the fact that 13 Greek astronomers have participated successfully in the observational research programs carried out at this observatory and published their results in leading astronomical journals. Another important point is that, due to the predominant field of the research (stellar activity) conducted at the Stephanion Observatory, Greek scientists came in early contact and cooperation, which is continued ever since, with Ukrainian scientists who traditionally occupy a leading place in the research on stellar activity all over the world. This is obviously from the mentioned above, a brief account of the scientific work was done in Stephanion. A great percentage of this work was done in cooperation with the Ukrainian Astronomical Institutes. Today most of the Greek astronomers which are interested in optical astrophysics have the possibility to work in Greece. Apart of the 30-inch reflector of the Stephanion Observatory, two 1.23-m reflectors (at Kryonerio, Pelopones and Skinaka, Crete) with a wealth of auxiliaries and much more smaller telescopes are in their disposal while a Robotic 2-meter, fully equipped with auxiliaries, will be in operation on 2001. Many of them have cooperation with the Ukrainian scientists too. In concluding we may say that Greek-Ukrainian cooperation will be continued in the new century with the best perspectives and that the Stephanion Observatory plays a key role in this cooperation.

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