Publ. Astron. Obs. Belgrade No. 80 (2006), 265 - 268 *Contributed paper*

ORIGIN OF THE PHOTOSPHERICAL NETWORK – THE MAIN ASTROPHYSICAL RESEARCH OF ĐORĐE STANOJEVIĆ

JELENA MILOGRADOV-TURIN

Department of Astronomy, Faculty of Mathematics, University of Belgrade
Studentski Trg 16, 11000 Belgrade, P.O.Box 550, Serbia and Montenegro
E–mail: jelenam@matf.bg.ac.yu

Abstract. The work "Sur l'origine du réseau photosphérique solaire" of the first Serbian astrophysicist Đorđe Stanojević (1886) is his most important astrophysical work. It is at the same time the first astrophysical work amongst Serbs. Stanojević's idea was that the network seen on many Meudon observatory photographs of the solar photosphere is caused by irregular refraction in the solar atmosphere. He simulated the process by taking photographs of the grains on a rough wall through an ordinary window glass. In the paper "Sur la photographie directe de l'état barométrique de l'atmosphére solaire" (1887) Stanojević extended the research and came to the conclusion that the photospherical network is an indicator of the barometric state in the solar atmosphere. It was shown later by other authors that the large scale network is caused by irregular convection cells in the Earth's atmosphere.

1. INTRODUCTION

Đorđe Stanojević (graduated in Belgrade in 1881) was one of the students sent by the Serbian government for postgraduate training abroad. Their additional education should advance development of the newly formed state (1878). The first student who was expected to contribute to development of astronomy was Milan Nedeljković while Đorđe Stanojević was the second one. The most successful part of his stay abroad was work in *Observatoire D'Astronomie Physique de Paris sis à Meudon*, supervised by the famous French astrophysicist Jules Janssen.

At the time Stanojević arrived, Janssen was a world wide known sixty years old scientist. His particular interest was the Sun. He became famous for discovery of a method which allows observations of solar prominences on the limb outside eclipses and for noticing first a spectral line attributed later to an element unknown on Earth - helium. The French government founded for Janssen the Observatory for Physical Astronomy at Meudon, in 1876. The first result he obtained there by photographing the Sun was the discovery of a netlike feature on the solar disc. Janssen described it under the name *réseau photosphérique solaire* in a note to *Académie des Sciences de Paris*, in 1877. Soon after the discovery he proposed an explanation: the network is a real phenomenon in the photosphere caused by motion of solar gases. Soon afterwards two other authors Huggins and Langley (e.g. Stanojević, 1886) assuming the network is a photospherical feature gave somewhat different explanations of motion.

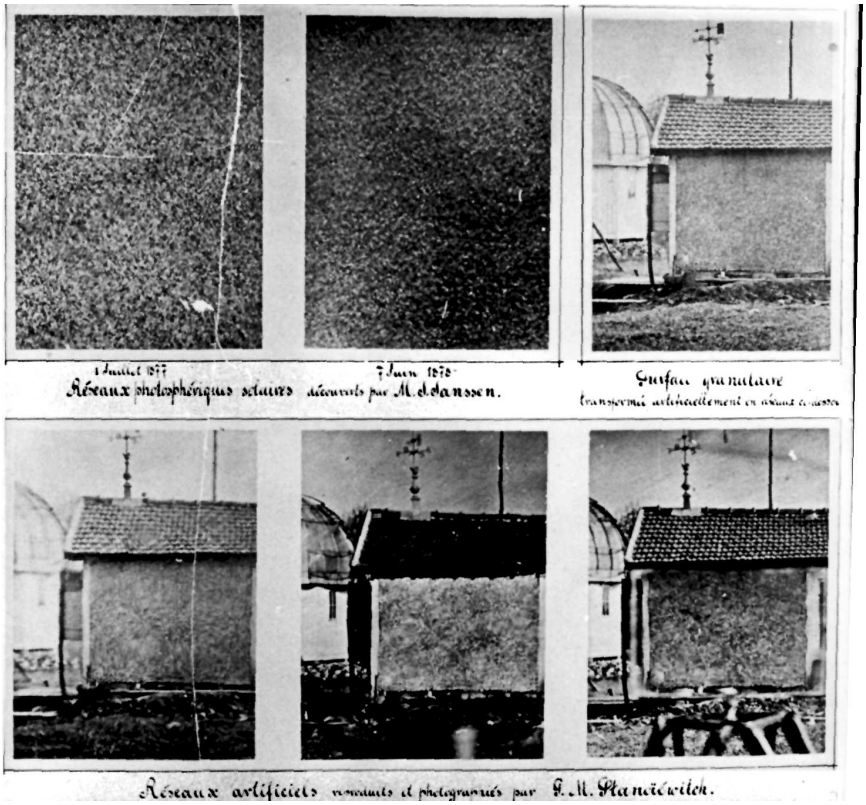

Figure 1: Composite print: upper left corner - Solar photospherical nets discovered by Mr J. Janssen, photos taken on the 1st of July 1877 and the 7th of June 1878, upper right corner - Granulated surface transformed artificially in the nets below, lower row - Artificial nets reproduced and photographed by G. M. Stanojević.

Stanojević was firstly assisting Janssen in measurements of spectra of atmospheric gases (1884-86) and then got involved in research of the solar photosphere structure (1886-87) resulting in two papers.

2. THE PHOTOSPHERICAL NETWORK

As it can be seen in the introductory part of the Stanojević's paper "Sur l'origine du réseau photosphérique solaire" he was very well informed about Janssen's discovery and the reaction of the scientific community. He got very interested in the photospherical network and even started to photograph the Sun at the Janssen's observatory.

Stanojević said in the paper that the starting point of his photospherical research was an optical phenomenon observed while he was helping Janssen in a research of absorption spectra of the air. Velocity changes of the air in the tube were producing a dark band of a variable width, perpendicular to spectral lines, along the whole spectrum. This phenomenon gave him an idea to search for the cause of the photospherical

net in the irregular refraction of light beams.

In order to find an experimental proof of his idea, Stanojević observed grains on the wall of the neighboring house through a small refractor. Inserting an ordinary glass window at an appropriate distance he could see a network similar to the photospherical one on the image of the wall.

Therefore he drew the following conclusions:

1. Irrelevantly whatever the origin of the solar granulation is, photospherical nets do not exist on the surface of the Sun.
2. Nets appear due to irregular refraction in a transparent body of an irregular molecular constitution placed between a granular surface and the camera.
3. The irregular refraction is produced by the gaseous solar envelope agitated by currents from all directions, representing on the whole a body of the most irregular molecular structure.

Although having a different view Janssen communicated Stanojević's note to the Paris Academy which published it in Comptes rendues (Stanojević, 1886).

3. THE BAROMETRIC STATE OF THE SOLAR ATMOSPHERE

Stanojević's paper "Sur la photographie directe de l'état barométrique de l'atmosphère solaire" (1887) is an extension and continuation of his first work.

After the publication of his first paper Stanojević asked Janssen for permission to look at all solar photographs taken in the previous eleven years. In due course he inspected more than 4000 photographs and gathered additional support for his theory. He found cases where a net was overlaid not only over images of granules but also over images of sunspots and faculae. The nets were moving.

Stanojević logically concluded that the net must get formed above the photosphere. He felt obliged to search for origin in the solar atmosphere. He thought that clear and foggy parts mark places where the largest differences in atmospherical pressure exist. i.e. at a given moment they are maxima and minima of the atmospherical pressure.

Stanojević noticed on some prints a net within the main net. He attributed the secondary net to the irregular refraction in the terrestrial atmosphere.

4. REACTION IN SERBIA

After return to Serbia in the second half of the year 1887, Stanojević submitted the paper "Solar photospherical networks" to the Royal Serbian Academy of Sciences. Stanojević intended, as he wrote, to present information about solar photospherical networks research in the native language since the subject was hardly known in Serbia. He wished to do it extensively since Paris Academy of Sciences has not allow papers longer than three pages.

The Royal Serbian Academy of Sciences appointed academician Ljubomir Klerić as a referee who wrote a negative review. Academy accepted his opinion and taking into account that major ideas presented in the paper were already published by Stanojević in Paris decided not to publish it in the Academy journal "Glas".

Rejection has upset Stanojević very much. He published an article about it in the general public journal "Otadžbina" (1888). In the first part he presented a review concerning networks on solar photographs: Janssen's discovery of photospherical networks, the hypotheses about their origin by Janssen, Huggins and Langley, his own research and reaction of the world to his results. In the second part he presented the official letter from Academy and strong arguments against Klerić's text. Polemics continued with the temporary secretary of the Academy Žujović but did not bring a change of Academy opinion.

Stanojević got very disappointed and turned more to Physics since then. His career as a solar astrophysicist practically ended. He never became an academician.

5. NEW VIEWS

Although Janssen must be praised for his Atlas of very high quality photographs taken since 1876 till 1903, many of them unsurpassed till the middle of the XX century, the network on many of them turned not to be a solar feature. Janssen was alive when the first indications of it were published. Stanojević had a chance to see that he was right in his judgement that the network has not originated in the solar photosphere. He was near the truth saying that it is a consequence of irregular refraction in an inhomogeneous medium. He could see that the terrestrial atmosphere was the medium responsible for the network on photographs. His basic misjudgment was attribution of the major role to the solar atmosphere.

The verdict was brought by investigations of Hansky (1905, 1906, 1908) and Chevalier (1908, 1910, 1912) who gave strong evidence against reality of photospherical network (e.g. Keenan, 1953). Network appears due to irregular convection cells in the terrestrial atmosphere (e.g. Minnaert, 1953). Chevalier suggested that the convection was happening in the heated air near the enlarging lens (e.g. Keenan, 1953).

Acknowledgements. Thanks are due to the Historical museum of Serbia which kindly provided prints from the original plates making initially this study possible and to professor Dragan Trifunović who kindly gave a reprint reproduced above.

This work is a part of Project 1471 supported by the Ministry of Science and Environmental Protection of the Republic of Serbia.

References

Janssen, P.J.C.: 1877, Sur le réseau photosphérique solaire, *C. R. Acad. Sci.*, **85**, 775.

Keenan, P.C.: 1953, Photography of the Sun's disk in integrated light, in The Solar System I, The Sun, ed. Kuiper, G. P., Chicago: The University of Chicago Press, 598.

Minnaert, M.: 1953, The Photosphere, in The Solar System I, The Sun, ed. Kuiper, G.P., Chicago: The University of Chicago Press, 169.

Stanojević, Đ: 1886, Sur l'origine du réseau photosphérique solaire , *C. R. Acad. Sci.*, **102**, 853.

Stanojević, Đ: 1887, Sur la photographie directe de l'état barométrique de l'atmosphère solaire, *C. R. Acad. Sci.*, **104**, 1263.

Stanojević, Đ: 1888, Sunčeve fotosferske mreže pred kraljevsko-srpskom Akademijom prirodnih nauka, *Otadžbina 7*, **20**, 595.