Solar searchlight effect: exploring solar activity through hydrogen glow observations

The Sun is the star closest to us that we have been studying for over 400 years. Observations with the unaided eye are difficult and dangerous, but a small telescope with an appropriate filter allows us to see the Sun's disc. It is thanks to such observations that we know that our Star is not homogeneous and that darker spots (called sunspots) or strange loops visible at the limb (the prominence) are visible on its surface. But only images taken by space telescopes revealed amazingly beautiful and intricate structures on the surface of the Sun.

Our star is very active. Even during relatively calm periods known as the solar cycle minima, its surface resembles the gurgling surface of boiling water. Although we know the Sun better than any other star, there are still questions to which we do not know the answers. One of the Sun's well-kept secrets is the origin and structure of the solar wind - a stream of charged particles that leave the Sun at speeds of up to several hundred kilometers per second.

Thanks to many instruments that constantly monitor the Sun (such as the SOHO satellite), we know that the greatest ejections of the solar wind come from magnetically active regions of the Sun. Mass ejections resembling powerful eruptions, plasma plumes, sudden brightening - all of these unusual phenomena, the careful analysis of which allows us to understand how the Sun and other similar stars work.

One of the manifestations of solar activity is increased emission in the spectral line Lyman-α (wavelength λ=121.567 nm), which is one of the strongest lines in the ultraviolet part of the solar spectrum.

The Lyman-α photons are absorbed by the neutral hydrogen flowing through the Solar System. Due to the absorption of the photon, the hydrogen atom is excited and then returns to its ground state, emitting another photon with the wavelength of Lyman-α. These emitted photons go to our detectors and are observed as the backscatter hydrogen glow. The advantage of this type of observation of the sky is the fact that we can see the reflection of the entire Sun's surface in it.

Most of the direct observations of our star are made from the ecliptic plane, where it is much easier to place the satellite. Therefore, a careful study of the hydrogen glow can help us answer the question of what the solar wind and solar radiation look like not only around the ecliptic but also at higher heliographic latitudes.

Active regions on the Sun behave like searchlights that we can observe in the image of the heliospheric glow. This project aims to find the relationship between the active regions on the Sun and the bright regions in the images of the hydrogen glow. To do this, we need to find those bright areas on the hydrogen glow maps and the active areas on the Sun that correspond to them. The effect is quite subtle so it will take a lot of careful work.

Next, we want to relate the properties of both of these phenomena with each other. We will create a system that will allow predicting the brightening of the hydrogen glow based on the observation of the solar disc. This will help us cleanse the helioglow observations of those reflections that interfere with the search for the solar wind signature.

Another application of the developed correlation will be a prediction of the appearance of bright, active regions on the Sun facing the Earth by observing the backscatter glow. This method works even when the active area of interest is on the invisible side of the Sun. It will allow us to create an early warning system against potential outbursts in the Sun that may threaten devices operating in the Earth's orbit.

As a result, a comprehensive database will be developed, that could be successfully used in other projects related to the study of solar activity and analyzing Lyman-α radiation.