Reg. No: 2018/31/D/ST9/02852; Principal Investigator: dr Izabela Kowalska-Leszczyńska

SOLAR WIND STRUCTURE: WHO IS RIGHT?

The heliosphere is an unique experimental field. We have so many different ways to investigate it and still there is so much to discover and understand. In the center there is a Sun - middle age average star that emits photons and solar wind. Outside there is a cloud of hydrogen and helium called Local Interstellar Cloud. The ionizated particles are blocking by the magnetic field, but neutral atoms penetrates heliopause (the boundary where solar wind meets with interstellar medium) and travel near the Sun.

Investigating the properties of the solar wind is a hard task. One way to do that is to observe how the neutral hydrogen is glowing when it interacts with the photons from the Sun. Those observations are much more complicated to interpret, because there are many factors involved. We need to know where is neutral hydrogen in the heliosphere, what is the temperature and velocity there. The answer to those questions is "numerical Warsaw Test Particle Model" (nWPTM) developed in Space Research Centre (Polish Academy of Sciences). Then we need to know what kind of photons are emitted by the Sun and how often are they absorbed by the hydrogen atoms. After absorption hydrogen atom will emit different photon in different direction. Part of those emitted photons is observed as a backscatter glow. One of the instrument that is observing that glow is SWAN on SOHO satellite. In future there will be another one - The Global Solar Wind Structure (GLOWS). This instrument will be build in Polish-German collaboration lead by dr hab. Maciej Bzowski from Space Research Centre.

The main goal of this project is developing a new solar wind structure and verify exiting models that are not consistent with each other. In order to accomplish this task a series of step needs to be done.

First we need to enhance radiation pressure model. Radiation pressure is a force that is acting on hydrogen atoms. Some photons are preferably absorbed by the atoms (in a case of hydrogen those photons are in Lyman-α spectral line $\lambda = 121.567$ nm). When they are absorbed they are gaining additional momentum. In a case of hydrogen this effect is comparable to the gravitational force from the Sun. Therefore when we are calculating trajectories of hydrogen atoms we need to take into account not only gravitation, but also radiation pressure. We will calculate that model including absorption and re-emission effects (that was neglected before).

Then, we will calculate Lyman-α backscatter glow using nWPTM. We will compare this model with SWAN observations and in future with GLOWS observations.

The final step will be reconstructing the solar wind structure. One of the models in literature that is based on SWAN observations is showing very strange structures on middle heliolatitudes, while observations from Ulysses (one of the few direct observations of solar wind outside from ecliptic plane, but incomplete and time limited) are not showing anything unusual. Who is right?

Additional product of this project will be Mock Data Challenge (MDC) - an exercise in which we will produce a fake observations of backscatter glow that would be seen by GLOWS instrument and then we will perform data analysis as if those were real observational data. That will allow us to test and improve our pipelines and algorithms.

The results of this work will be applied to data analysis in present and future projects. Radiation pressure model will be used in IBEX-Lo and IMAP-Lo analysis, while backscatter glow and solar wind structure will be used for planning and analyzing data from GLOWS detector.