

The solar atmosphere, i.e. the medium above the visible surface of the Sun, has been traditionally described as a stack of layers, which are magnetically structured and gravitationally stratified and exhibit a diversity of physical phenomena, making the Sun a highly interesting plasma physics laboratory. The lowest solar atmospheric layer is called the photosphere with its temperature of 5600 K, and it is 10000 times more rarefied than a laboratory-gained vacuum. Right above it is the solar chromosphere that is about 1500 km thick. The temperature surprisingly rises in this layer until higher up in the corona where it reaches a magnitude of about 1 MK. The corona extends to about 2-3 solar radii and it passes smoothly in the solar wind which is the stream of solar particles, reaching the Earth and beyond. Apparently, as a result of their low temperatures the photosphere and chromosphere consist of a number of neutrals, while the corona is essentially fully ionized. So, the chromosphere marks the transition between very different neighboring layers.

The treatment of energy flow from deeper and colder solar layers and the heating of the outer and hotter regions is the main problem of solar physics, and it is still in its infancy as long as its physical understanding is concerned. Solar observations reveal that a diversity of waves propagate throughout the solar atmosphere among which Alfvén waves, that are incompressible and are guided by magnetic field lines, were recently found to be capable to heat the outer solar atmospheric regions (Srivastava et al. 2017). However, the mechanism of energy conversion from these waves and its deposition in the form of thermal energy remains unknown. We propose that ion-neutral collisions may be efficient enough to transfer energy from Alfvén waves and convert it into thermal energy, leading to the plasma heating.

Another cardinal issue associated with heliophysics is the solar wind generation. In the terrestrial environment wind results from pressure difference between two regions; the wind flows from the high-pressure atmospheric region to a low-pressure system. In the solar atmosphere, the wind must be affected by magnetic field, but the process of wind generation remains largely unknown. It was recently proposed that the solar wind is efficiently generated by chromospheric spicules which are jets of cold plasma ejected from the chromosphere into low coronal regions. Here, we propose to generalize the recent model into its 2-fluid equivalent which takes protons and neutral hydrogen atoms into account.

The main goal of this proposal is to perform numerical simulations of the atmospheric heating and generation of the solar wind. These simulations will be performed with the use of recently devised JOANNA code for the partially-ionized solar atmosphere. These simulations will be applied to explain recent and future observational findings, i.e. to reveal and better quantify the physical mechanisms resulting in heating of the chromosphere and corona, generation of the solar wind, and the propagation of waves through the chromosphere that is a layer in which the medium jumps from collisional to collision-less, from neutral to essentially fully ionized and increases by about 200 times in temperature. JOANNA is a highly flexible and massively parallel numerical code which embraces a multi-physics such as ion-neutral drag force and ionization/recombination. This proposal aims to clarify recent (Hinode), current (IRIS, SST/CRISP), and future (DKIST, EST) observations of finely-structured solar atmosphere. Thus, the suggested science is timely, certainly far at the forefront of the current academic research in the field of heliophysics and numerical methods, extremely important, and of the highest scientific level. The contemporarity of the proposal, the novelty of the approach, and the capacity of the group members ensure that the obtained results will be published in the high-quality journals.