

## **The Subparsec Structure of the Local Interstellar Medium**

Even though the outer space is often considered an example of nearly a perfect vacuum, it is filled with a very low-density mixture of various particles. The most abundant species are electrons, protons, helium ions, hydrogen and helium atoms. In the Earth's space environment, the source of ionized matter is the Sun, which continuously emits the solar wind – a stream of protons, electrons, and other ions into outer space – which creates a bubble, known as the heliosphere, that extends far beyond the orbits of the Solar System planets. The heliosphere shields the Solar System from most charged particles from the surrounding interstellar medium. However, electrically neutral particles, such as atomic hydrogen and helium, enter the heliosphere and are detected by instruments placed in outer space.

The interstellar medium consists of various phases characterized by density, temperature, and composition. Hotter regions are less dense and are fully ionized, while colder regions are denser and not ionized. Based on observations, we know that we are inside a partially ionized region of intermediate temperature and density. We infer the properties of the surrounding region based on the observations of interstellar neutral atoms entering the heliosphere and measured with space instruments.

The local interstellar medium is also studied using astronomical observations, for example, by observing the light absorption by atoms and ions along the lines of sight to nearby stars. Atoms and ions can capture photons of specific wavelengths, creating an absorption spectrum. These observations allowed for the identification of several partially ionized warm regions in the Sun's neighborhood called interstellar clouds. In an area extending about 50 light-years from the Sun, about 15 clouds have been discovered moving at different velocities relative to the Sun. However, the smallest scale structures that can be studied have a size of approximately a parsec (1 parsec = 3.26 light-years).

Measurements of interstellar neutral atoms show that the velocity of the local interstellar medium around the heliosphere is intermediate between the velocities of the two closest interstellar clouds identified in astronomical observations. Therefore, we may be in an interaction region between those two clouds. In this research project, we will investigate this possibility by modeling possible interaction scenarios and comparing the predictions from these models with the observations of interstellar neutral atoms. We plan to include observations from the new NASA's Interstellar Mapping and Acceleration Probe (IMAP) mission. The detector of interstellar atoms on board this mission has new capabilities that will help us to describe the local interstellar medium.

The project will help us narrow the gap between the structures in the local interstellar medium identified by astronomical methods (larger than 1 pc) and structures in the heliosphere (less than 0.001 pc). The project also challenges a key assumption of heliospheric studies: that the interstellar medium surrounding the heliosphere is in thermal equilibrium and homogeneous. Therefore, the project's results may impact future heliospheric studies.