

In nature, everything we see around us — planets, stars, and even our bodies — is made up of atoms. But what happens when two atoms collide at incredibly high speeds? This process, called fusion, is one of the most fundamental interactions in the universe. It powers the stars, including our Sun, and creates many of the elements we find on Earth.

Fusion happens when atomic nuclei come close enough to merge into a single, larger nucleus. However, this is not easy because the positively charged particles in the nuclei repel each other. Only at very high energies — like those in the core of a star — can fusion occur. Surprisingly, scientists have discovered that at very low energies, fusion becomes even harder than expected. This puzzling behavior is called "fusion hindrance," and we are working to understand why it happens.

Our project focuses on studying fusion reactions involving medium-light nuclei, like neon and silicon. These atoms are slightly heavier than those commonly found in stars but provide valuable clues about fusion in extreme conditions. To do this, we use beams of fast-moving nuclei, traveling at about 10% of the speed of light, and aim them at thin layers of material. When the nuclei collide, new elements are created, and has to be separated from the ions of incoming beam.

One of the key tools in our experiments is a specialized device called a Wien Filter. This advanced system helps us separate the fusion products from other particles, allowing for more accurate measurements. The Heavy Ion Laboratory in Warsaw is uniquely equipped for this kind of research, especially with its ability to produce rare neon beams.

Fusion hindrance remains one of the most intriguing mysteries in nuclear physics. Experimental results show that fusion rates drop unexpectedly at low energies. Understanding this phenomenon requires detailed measurements of how nuclei interact under these conditions and testing advanced theoretical models. By focusing on medium-light nuclei, which have properties bridging light and heavy nuclei, we aim to uncover universal patterns governing nuclear behavior.

The experiments in our project involve creating a controlled environment to replicate the fusion process. Beams of accelerated nuclei collide with targets, forming by fusion new nuclei. Detecting and analyzing these processes requires a combination of sophisticated detectors. The precise data collected will allow us to reconstruct the fusion events and investigate the conditions under which hindrance occurs.

This research has broader implications beyond nuclear physics. Fusion is central to understanding how the elements in the universe were formed. In stars, nuclear fusion drives the production of heavier elements. By studying fusion in the lab, we gain insights into these cosmic phenomena, enhancing our understanding of stellar evolution and the chemical composition of the universe.

Through this project, conducted at the Heavy Ion Laboratory in Warsaw, we aim to advance our knowledge of nuclear fusion. By uncovering the secrets of fusion hindrance, we hope to answer fundamental questions about the forces that shape the universe and open new pathways for scientific discovery.