

Antimatter tweezers for nuclear editing

Precise manipulation of single atoms with optical tweezers allows scientists to construct custom structures at atomic level. At molecular level, DNA chains can be precisely edited using the CRISPR-Cas9 genome technique. Existence of these precise tools has commenced new research fields in nanotechnology and biology at the frontier of knowledge.

At the subatomic level we don't have such tools that could let us manipulate nuclei. The building blocks of known nuclear matter, protons and neutrons, are kept together by the strong force and enormous energies are needed to break those bonds. The main techniques to produce radioisotopes are the natural decay chains and particle accelerator-based processes as nuclear fragmentation and spallation in high energy collisions of accelerated protons or ions and nuclei. In all cases these mechanisms set important limits on the production types and lifetimes of possible isotopes.

We propose a precise tool to sculpt nuclei using antimatter. Antiprotons are the antimatter partners of protons. They have the same electric charge as electrons. In certain cases, they can substitute them in an atom which becomes a subtype of *exotic atoms* called *antiprotonic atoms*. Due to its nature, the antiproton will annihilate on the surface of the nucleus. When this process occurs with trapped atoms cooled down to just a few K above the absolute zero, the resulting selected fragments might be captured by strong electromagnetic fields. This would enable the production of a broad range of long and short-lived cold nuclei isotopes, already stripped of electrons, trapped and ready for further experimentation or accumulation.

CERN, the European Organization for Nuclear Research, located in Geneva, is one of the world's largest and the most respected scientific research centres. The laboratory has contributed to the understanding of fundamental physics on extreme low and high energy scales. Antimatter is scarce in our Universe and it's only world's abundant artificial source is located at the Antiproton Decelerator facility at CERN. It provides a beam of antiprotons to experiments doing antimatter research. Among them, the design of the AEGIS experiment is especially suited for this study. The detector has a set of two superconducting magnets used to trap and accumulate antimatter and other particles and atoms as well as a large ultra high vacuum vessel and lasers to study the production of radioisotopes.

This new scheme to manipulate nuclei with antimatter can open a new avenue in nuclear physics allowing scientists to access a wide range of isotopes in a clean and controlled vacuum environment. Custom made nuclei would provide a bridge to the sub-nano precise edition and design of nuclear matter.