New super-heavy nuclei at GANIL

Using the GANIL accelerator (CEA-CNRS, Caen, France), a team of physicists has successfully created and identified elements with nuclei containing 120 and 124 protons, whereas uranium, the heaviest natural element, contains only 92 protons. The results were recently published in Physical Review Letters.

The nucleus of an atom is composed of protons and neutrons. Atoms containing a large number of these particles are considered to be "heavy". With its 92 protons, uranium is the heaviest naturally occurring element on Earth. Atoms containing more protons tend to be highly unstable and can only exist for very short periods. However, researchers predict that an "island of stability" exists for atoms having a much higher number of protons than uranium. Various experiments in several countries aim at creating heavier and heavier elements to reach this island of stability. The heaviest element synthesised to date has 118 protons.

So-called "super-heavy" elements (containing more than 110 protons) are generally formed by fusion reactions between two lighter nuclei. One of the main challenges in trying to synthesise these elements is the inevitable excitation of the nuclei in the form of temperature and strain, generated during their formation by fusion. The nuclei become extremely unstable when excited and fission into two lighter nuclei, long before reaching a detector where they could be observed directly. Because of the significant instability of fusion, the possibility of using it to form heavy nuclei has been very uncertain, until now. A novel approach for detecting super-heavy elements and their stability has been developed at GANIL as part of a collaborative effort between several laboratories : rather than detecting the super-heavy compound nucleus (produced by fusion), the approach instead measures fission time.

Nuclei closer to a stable state take longer to fission. During recent experiments with GANIL, physicists probed very long fission times using the "blocking technique in single crystals" .
Fission events with times exceeding 10 18 s (one billionth of one billionth of a second) were observed for nuclei containing 120 and 124 protons. These nuclei were formed by bombarding nickel and germanium targets with uranium ions accelerated by GANIL. They were identified using INDRA, a nuclei and charged particle detector

covering nearly all the space around the targets. The time of 10 18 s is obviously very short, but it is long enough at the scale of nuclear lifetimes to unambiguously signal the formation of elements with 120 and 124 protons and to significantly stabilise them with regard to fission when they are not in an excited state. These results open new perspectives in the race towards super-heavy elements and in locating an "island of stability".

Countries

Austria, Belgium, Bulgaria, Cyprus, Czechia, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, United Kingdom

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