Hafnium Bomb

Nuclear isomers include excited states of nuclei that electromagnetically decay slowly enough for energy storage. However, the emitted gamma rays of the isomer decay come in a burst. Controlled triggering of the isomer decay allows stored energy to be released on demand, and nuclear isomers represent a potential stand-alone energy source. Barriers to developing a practical energy source are triggering and production.

The so-called nuclear isomer materials have the theoretical potential for 100 to 1,000 times the energy density of conventional energetic chemical compounds. These materials are of two varieties: shape isomers and spin isomers. In both types, energy is released in the form of gamma rays when the nuclei of the material transition from a higher energy state to a lower. Nuclear isomers, such as Os187, Yt186, Ta180, and Zn66 have been discussed as possibilities. Nuclear isomers, such as hafnium 178m2, store in the nucleus 10,000 times as much energy per gram as TNT.

In theory, isomer high-energy density materials (HEDMs) have potential energy yields orders of magnitude greater than existing chemical energetics. While the development of useful propellants, explosives, or energy sources based on this phenomenon is probably decades away, such extraordinary energy density has the potential to revolutionize all aspects of warfare. Potential applications range from very high-density energetics for propulsion and warheads to high-energy and power density primary sources to address requirements for EM launchers and all-electric propulsion.

The goal of DARPA's Stimulated Isomer Energy Release program is to develop a technique to control the release of this energy. It will develop a way to make these isomers in gram-size quantities. The program will demonstrate that as much energy can be released as is used to initiate the reaction (a breakeven experiment). Program Plans outlined in February 2004 include efforts to determine if the hafnium isomer can be triggered with photons in the x-ray range that will release more than 50 times the energy input of the trigger. The project intended to identify a hafnium isomer production process that is affordable and cost effective, and to develop a physics approach to a chain reaction for the hafnium isomer.

DARPA supported a group led by Carl Collins at the University of Texas at Dallas. In early 1999 Collins claimed to have demonstrated triggering energy release from a hafnium-178 isomer using a dental X-ray machine (Physical Review Letter 25 Jan, 1999). The Collins groups claimed that when they bombarded the metal with soft X-rays, the hafnium-178 released a burst of gamma rays 60 times more powerful than the X-rays.

In 2001 physicists from the Lawrence Livermore National Laboratory, in collaboration with scientists at Los Alamos and Argonne national laboratories, conducted tests that strongly contradicted reports claiming an accelerated emission of gamma rays from the nuclear isomer 31-yr. hafnium-178, and the opportunity for a controlled release of energy. The triggering source in the original experiment was a dental X-ray machine.

Using the Advanced Photon Source at Argonne, which has more than 100,000 times higher X-ray intensity than the dental X-ray machine used in the original experiment, and a sample of isomeric Hf-178 fabricated at Los Alamos, the team of physicists expected to see an enormous signal indicating a controlled release of energy stored in the long lived nuclear excited state. However, the scientists observed no such signal and established an upper limit consistent with nuclear science and orders of magnitude below previous reports. When the team turned the APS X-ray beam onto the sample of 31-yr. Hf-178, no detectable increase of the isomer decay occurred. In other words, the X-ray irradiation did not decrease the time it takes for hafnium to decay; a result that is consistent with nuclear physics.

Anatoli Andreev of Moscow State University wrote in 2007 "Recently, there have been reports in the mass media about plans to build what became known as an “isomeric bomb” based on Hf-178. What all the publications are speaking about is no less than the possibility of building a radically new weapon that does not fall under a single article of the existing nonproliferation treaties. The publications were based on the sensational results on induced decay of the long-lived isomer Hf-178m2 (16+, 2446 keV, 31 yr), obtained in 1999-2004 by a group of researchers headed by Carl B Collins, the Director of the Center for Quantum Electronics, University of Texas at Dallas.

"Our results show the following. The production of several grams or more of the isomer 178m2-Hf is an extremely difficult task. So far, no effective process for such production has been described in the literature. The use of only one of the above reactions will require large investments. Actually, such burdensome expenditures from state budgets may prove useless: no energy can be liberated by the method described in Collins’s articles. The cross sections of the induced decay of the isomer 178m2-Hf measured by that method do not agree with the current ideas about the physics of the nucleus and the physics of electromagnetic nuclear processes.

"Summarizing the obtained results, it would be noted the following. Theoretical calculations and the analysis of the existing experimental data suggest that the hafnium problem, as presented by the works of Collins's group, does not exist. The hullabaloo over the hafnium bomb was due to meaningless experimental data and the incompetence of certain individuals rather than to the real possibility of building a radically new weapon based on 178-Hf."

Further Reading

Links

- "Excitation Of Nuclei And Trapping Of Atoms In Optical Fields Of High Intensity", Anatoli Andreev, Moscow State University, 15-02-2007, ISTC Registration No: 2651
- Scary Things Come in Small Packages By Sharon Weinberger The Washington Post Sunday, March 28, 2004; Page W15
- Conflicting Results on a Long-Lived Nuclear Isomer of Hafnium Have Wider Implications Bertram Schwarzschild Physics Today May 2004
- Gamma Ray Weapons? A Premature Speculation by Kurt Gottfried, October 7, 2003
- ATOMIC PLANES IN THE WORKS? noahmax Defense Tech May 19, 2004

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