Physicists look for ways to protect satellites' electronic equipment in space

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The Department of Micro- and Nano-Electronics at the National Research Nuclear University MEPhI (Russia) has presented a new method of predicting integrated microcircuit failures in outer space. An article on the research has been published by *IEEE Transactions on Nuclear Science*.

Ensuring the reliable operation of microcircuits in outer space is an important scientific and economic objective. For modern weather, communications and surveillance satellites to be cost-effective, they need to be operational for at least 10 to 15 years. Onboard electronic equipment failures are a common reason for early satellite failure.

Standard electronic equipment used in terrestrial conditions is too unreliable for employment in space. This is why electronic equipment intended for space flights is either manufactured with special materials or is selected and tested in a specific way. All of this calls for specific insight into physical processes in circuits and is what motivates scientists to develop mathematical methods to predict circuit behavior under various conditions.

Of much importance here are so-called single effects, or faults of electronic circuitry caused by high-energy space particles from the Earth's radiation belts or from the depths of the galaxy. The single fault problem emerged in the early 1980s, when microelectronic components were measured in microns (one-millionth of a meter).

What makes this problem particularly acute is that space-borne electronic equipment cannot be screened from high-energy particles because of their penetration power. To resolve this, methods to predict the frequencies under prescribed conditions were developed as were software- and hardware-based solutions to block the particles.

But technology has changed dramatically in the last 30 years. With circuitry elements reduced to a nanoscale, failures have become more frequent, with just one space particle (e.g., an ion or a proton) capable of causing a fault in a logic chip or a memory cell at once, thus leading to failure or irreversible damage in circuit. It is very hard to mend these failures because of their uncertain multiplicity factor, that is, the number of failures caused by one space particle.

MEPhI researchers have addressed this problem in the last couple of years, coming up with a new methodology that makes it possible to process data from ground-based experiments and program failure frequency calculations. It enables forecasts based on new physical, technological and programming parameters characteristic of nanosize (technological norm lower than 100 nm) cutting-edge integrated circuits.

"The gist of the matter is the non-local nature of impacts: one space particle can affect several elements in integrated circuits. It is this factor and the uncertain multiplicity factor that make it impossible to predict the frequency of failures and fend off faults with the old methods. This problem can become further aggravated as miniaturization technology continues and circuit architecture becomes more complex. This is why we have suggested a methodology to process experimental data and calculate the frequency of faults. This can help differentiate failures by a repetition factor and assess frequencies in prescribed space orbits, doing so quickly and reliably," said researcher Prof. Gennady Zebrev.