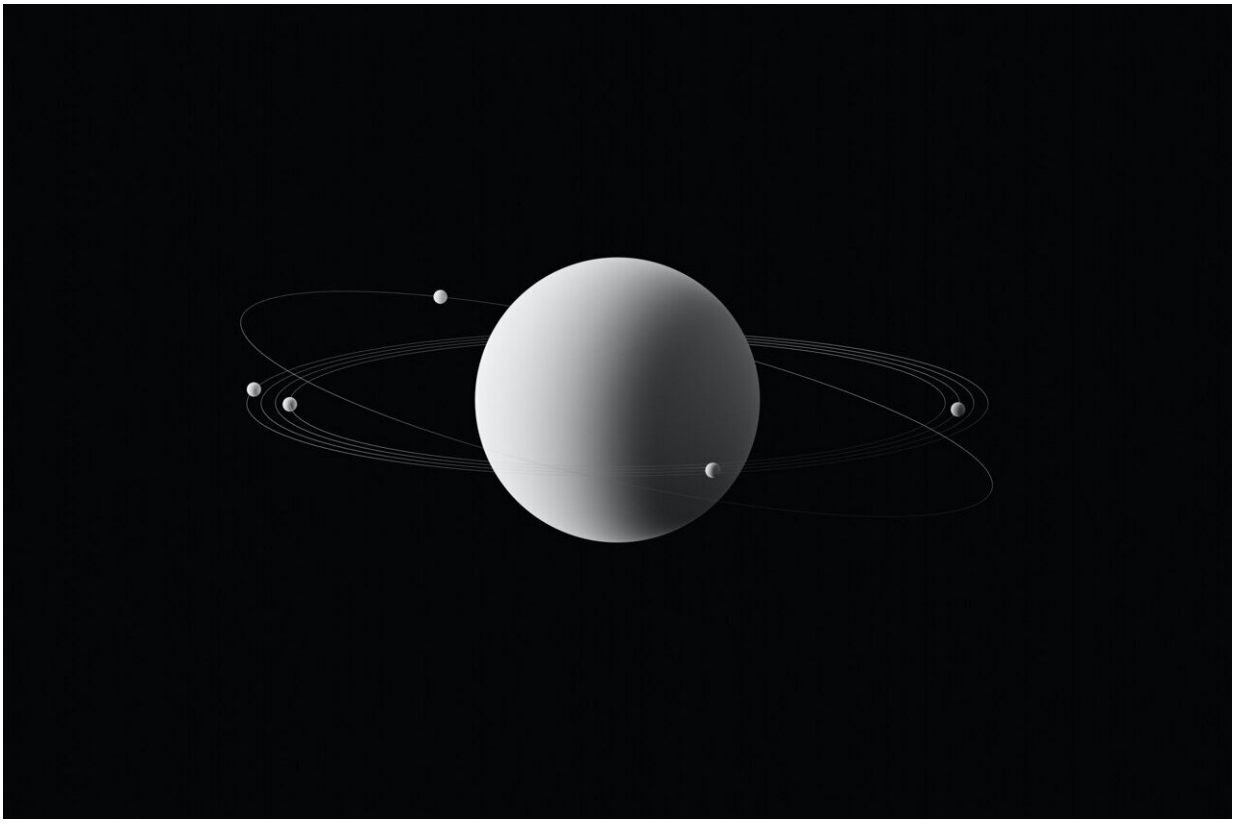
Towards single atom computing via high harmonic generation

February 16 2023, by Robert Lea



Credit: Unsplash/CC0 Public Domain

New research opens the horizons regarding what a "computer" can be and how small a computational unit can get

Considering a "computer" as anything that processes information by taking an input and producing an output leads to the obvious questions, what kind of objects could perform computations? And how small can a computer be? As transistors approach the limit of miniaturization, these questions are more than mere curiosities, their answers could form the basis of a new computing paradigm.

In a new paper in *EPJ Plus* by Tulane University, New Orleans, Louisiana, researcher Gerard McCaul, and his co-authors demonstrate that even one of the more basic constituents of matter — atoms — can act as a reservoir for computing where all input-output processing is optical.

"We had the idea that the capacity for computation is a universal property that all physical systems share, but within that paradigm, there is a great profusion of frameworks for how one would go about actually trying to perform computations," McCaul says.

He adds that one of the most important of these frameworks is neuromorphic or reservoir computing with a neuromorphic computer aiming to mimic the brain. This concept underpins the explosive development of machine learning and AI in the last few decades and leads to a potentially non-linear computer where output is not linearly proportional to the input. This is desirable as it could lead to a computing architecture flexible enough that any given output can be achieved, given a suitable input.

"That is, if we want some given computational result, we are guaranteed that some input to the computation exists that will achieve it," McCaul says. "This is impossible if our system only exhibits a linear response."

The team proposed a non-linear single-atom computer with the input information encoded directly into light and the output also in the form of

light. The calculation is then determined by filters that the light output is passed through.

"Our research confirmed this approach works in principle, as well as confirming the fact that the system performed better when the input light was designed to induce a higher degree of non-linearity in the system," McCaul says.

"I would probably argue that what we are trying to emphasize with this work is that the minimal system capable of computing really does exist on the level of a single atom and that computation can be performed purely with optical processes."

More information: Gerard McCaul et al, Towards single atom computing via high harmonic generation, *The European Physical Journal Plus* (2023). DOI: 10.1140/epjp/s13360-023-03649-3

Provided by Springer