atomic clock microwave cavity

An additively manufactured microwave resonator cavity for applications in double-resonance vapour-cell atomic clocks is presented by researchers of Université de Neuchâtel, Ecole Polytechnique Federale de Lausanne, and SWISSto12, Switzerland.

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The problem of measuring time accurately has a long and illustrious history. The need for an accurate measure of time has only ever increased as technology and society have progressed, and has now reached the point where only atomic clocks have the precision necessary to allow our modern world to function. Global positioning systems are one of the most notable instances of this, as without atomic clocks installed on the satellites responsible it would be impossible to determine position to within a meter tolerance.

“A smartphone is a good example to show how significant atomic clocks are in our daily life, even if they are not directly visible. Charging the phone, connecting it to the network, doing banking transactions, locating its position in unknown cities. All these operations require at one point the timing of an atomic clock,” explains Dr. Pellaton, part of a team who developed an additively manufactured microwave resonator cavity for applications in double-resonance vapour-cell atomic clocks, presented in this Issue of Electronics Letters.

Creating space

With all the demand for atomic clocks, it is imperative for researchers to come up with components that are better, cheaper, and easier to manufacture. With this in mind, the researchers turned to additive manufacturing, which had already been successfully used to help create other microwave devices such as waveguides and antennas, to 3D-print a microwave cavity resonator. This leads to a large reduction in weight, the need for assembly, and lead times, ideal for applications such as those in satellite construction.

Of course, there are some disadvantages to this method too. “For this application, the most critical one is a potentially high sensitivity of the resonant mode to temperature fluctuations, or to the ageing of the resonator, which could potentially degrade the stability performances of the clock in the medium to long term.”

Measuring the future

The research presented in Electronics Letters is a proof of concept, demonstrating the feasibility of this type of manufacturing by achieving competitive state-of-the-art short-term abilities. The researchers now intend to investigate the mid- and long-term stability performances. If these results are good, there are limitless opportunities for making components stronger, lighter, and easier to make. “AM practically sets the human imagination and laws of nature as the only limits for the design of 3D electromagnetic devices, getting rid of many practical manufacturing limitations,” Dr Pellaton says.

“In the short term, it could benefit the existing vapour-cell atomic clock industry, provided some deeper analysis. In the longer term, other types of atomic clocks might also benefit from this technology.”

The long-term goal is to get this technology used more widely by industrial manufacturers, convincing them with detailed characterization work. “As soon as industrials enter the game, we will be able to envisage more affordable compact clocks, and why not, to see this technology employed in space,” Dr Pellaton states. “The grail would be a miniature, robust, reliable, affordable atomic clock, enabled by among others AM technology that exhibits the same stability performances as current primary frequency standards.”

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