

# Changing color of light using a spatiotemporal boundary

November 29 2018

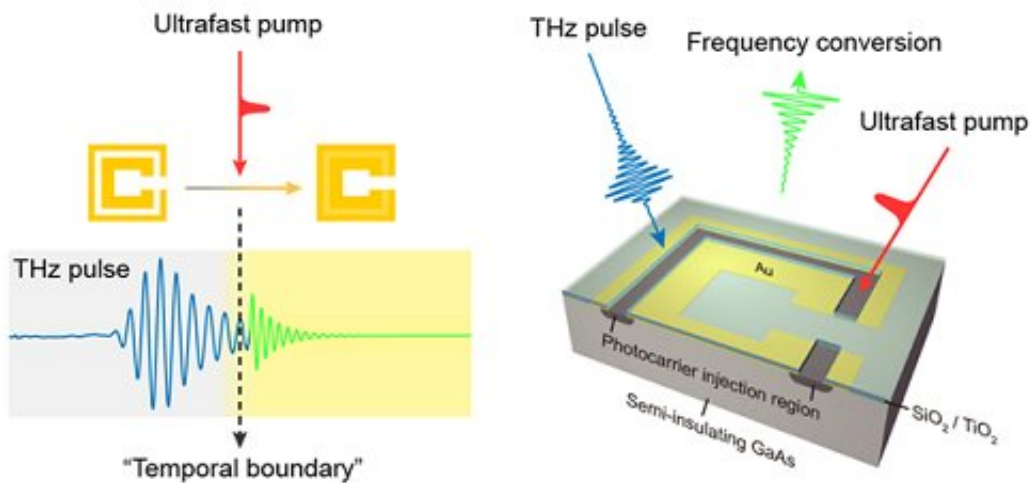


Figure 1. The frequency conversion process of light using a spatiotemporal boundary. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

A KAIST team developed an optical technique to change the color (frequency) of light using a spatiotemporal boundary. The research focuses on realizing a spatiotemporal boundary with a much higher degree of freedom than the results of previous studies by fabricating a thin metal structure on a semiconductor surface. Such a spatiotemporal boundary is expected to be applicable to an ultra-thin film type optical device capable of changing the color of light.

The optical [frequency](#) conversion device plays a key role in precision measurement and communication technology, and the device has been developed mainly based on optical nonlinearity.

If the intensity of [light](#) is very strong, the optical medium responds nonlinearly so the nonlinear optical phenomena, such as frequency doubling or frequency mixing, can be observed. Such optical nonlinear phenomena are realized usually by the interaction between a high-intensity laser and a nonlinear medium.

As an alternative method frequency conversion is observed by temporally modifying the optical properties of the medium through which light travels using an external stimulus. Since frequency conversion in this way can be observed even in weak light, such a technique could be particularly useful in communication technology.

However, rapid optical property modification of the medium by an external stimulus and subsequent light frequency conversion techniques have been researched only in the perturbative regime, and it has been difficult to realize these theoretical results in practical applications.

To realize such a conceptual idea, Professor Bumki Min from the Department of Mechanical Engineering and his team collaborated with Professor Wonju Jeon from the Department of Mechanical Engineering and Professor Fabian Rotermund from the Department of Physics. They developed an artificial optical material (metamaterial) by arranging a metal microstructure that mimics an atomic structure and succeeded in creating a spatiotemporal boundary by changing the optical property of the artificial material abruptly.

While previous studies only slightly modified the refractive index of the medium, this study provided a spatiotemporal boundary as a platform for freely designing and changing the spectral properties of the medium.

Using this, the [research team](#) developed a device that can control the frequency of light to a large degree.

The research team said a spatiotemporal boundary, which was only conceptually considered in previous research and realized in the perturbative regime, was developed as a step that can be realized and applied.

Professor Min said, "The frequency conversion of light becomes designable and predictable, so our research could be applied in many optical applications. This research will present a new direction for time-variant media research projects in the field of optics."

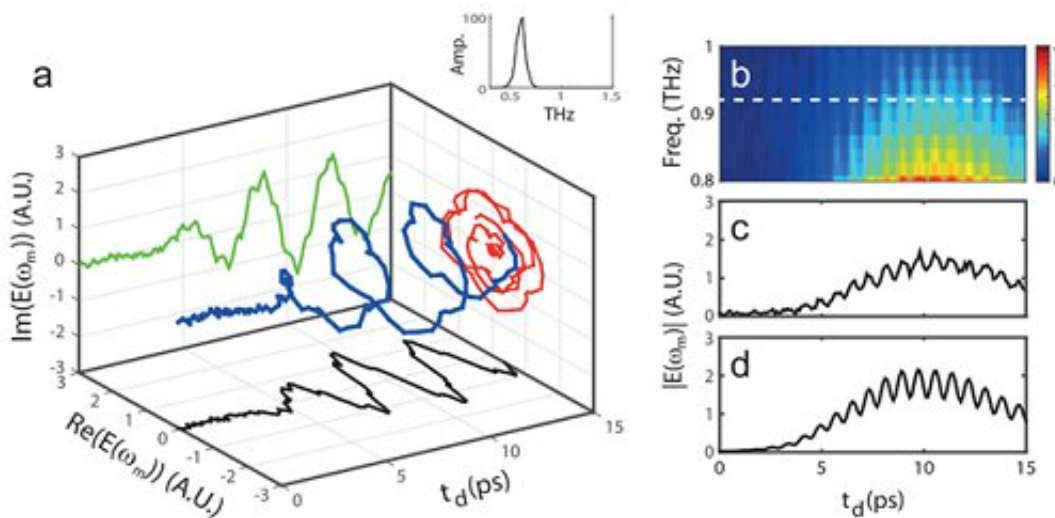


Figure 2. The complex amplitude of light at the converted frequency with the variation of a spatiotemporal boundary. Credit: The Korea Advanced Institute of Science and Technology (KAIST)

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**More information:** Kanghee Lee et al. Linear frequency conversion via sudden merging of meta-atoms in time-variant metasurfaces, *Nature Photonics* (2018). [DOI: 10.1038/s41566-018-0259-4](https://doi.org/10.1038/s41566-018-0259-4)

Provided by The Korea Advanced Institute of Science and Technology (KAIST)

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