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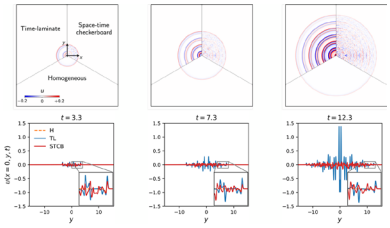
Composites with suitable space-time microstructures may unlock stable extreme wave phenomena.



Time-modulated metamaterials have instantaneously changeable properties which can facilitate new wave phenomena. However, realizing instantaneous time modulation is experimentally difficult and may cause instabilities. Mattei and Gulizzi propose design principles that enable researchers to properly develop time-modulated materials without instabilities.

The authors suggest that composite materials with the proper microstructures and composition could enable impinging wavefronts to propagate without instability – a known problem for homogeneous time-modulated materials whose properties have been changed repeatedly in time.

“The instability resulting from the exponential blow-up of the amplitude of the wavefront, if the time modulation is repeated, limits the implementation of such materials,” co-author Ornella Mattei said. “Our paper provides a solution to such a problem by offering a wide range of spatial composites that, if suitably time modulated, will experience wave propagation with no blow-up.”

The team’s solution uses properly placed interfaces in designed composite materials to cancel out any instabilities resulting from repeated time modulation.

“When a pulse encounters the physical boundary between two components of the composite material, that is, a space interface, it will split into two, analogously to what occurs at a time switch, or time interface,” Mattei said. “The main idea is to place such space and time interfaces cleverly so that the pulses generated by the splitting at each interface will interact positively. Specifically, the spatial geometry and the time switches have to be designed in relation to the wave speed of the component materials but not to the wave impedance that can be chosen arbitrarily.”

Mattei said the team will examine how their results change with nonlinear media. Their research may help applications such as coatings whose antireflective properties can be changed over time.

Source: “On the effects of suitably designed space microstructures in the propagation of waves in time modulated composites,” by O. Mattei and V. Gulizzi, *Applied Physics Letters* (2023). The article can be accessed at https://doi.org/10.1063/5.0132899.

This paper is part of the Time Modulated Metamaterials Collection, learn more here.