# New ultrasonic wave phenomenon leads to improved safety for society

September 13 2018

Credit: CC0 Public Domain

A research group led by Assistant Professor Yosuke Ishii at Toyohashi University of Technology has unraveled the phenomenon of a new "third ultrasonic wave" being generated when two ultrasonic waves intersect within a plate. This wave exhibits varying intensity in response to material damage and can therefore be used for nondestructively testing thin plate structures. This new technology surpasses conventional technology, enabling precise and nondestructive detection of fatigue and early damage.

Humans are unable to see the inside of an object with the naked eye unless that object is transparent. Using ultrasonic waves, however, can afford that ability. Ultrasonic waves reflect any defects present within a material. Therefore, measuring these waves reflected from defects can tell us if a material is damaged in any way. In other words, we can "examine" materials without having to break them open. This is the principle behind nondestructive testing using ultrasonic waves. We need nondestructive testing to improve the safety of humans, and how to increase testing accuracy is currently being studied around the world.

Currently, the field of nondestructive testing is researching techniques for testing the state of a material that is not damaged but has some wear. One prime example of a state that needs testing is fatigue. Like humans, materials also become fatigued. Even a small amount of load is enough to cause material fatigue when repeatedly applied. Fatigue creates minute amounts of damage in a material, which then become bigger and eventually cause the material to break. Thin plate materials are widely used in large-scale structures such as power plants built during Japan's period of high economic growth after World War II. Now that these structures are aging, it is crucial to use nondestructive methods to test their degree of fatigue. With current technology, we are unable to detect damage unless a large amount of damage (damage that can reflect ultrasonic waves) has actually occurred in materials. Because of this, it is of paramount importance to establish a technology that can accurately evaluate material fatigue when a minute amount of damage has occurred, or even earlier.

With this in mind, the research group turned its attention to "three-wave interaction." This is a phenomenon whereby two intersecting ultrasonic waves produce a third small ultrasonic wave within a plate. Through conducting numerical simulations and theoretical calculation, the research group succeeded in uncovering the mechanism behind how this third ultrasonic wave is generated by three-wave interaction. The third ultrasonic wave contains a large amount of information on the properties of a material, potentially making it possible to accurately test the early stages of material fatigue (before a large amount of damage occurs).

The research team aims to experimentally verify this new technology to create a new nondestructive testing method for thin plate materials which employs three-wave interaction. Establishing such a technology will make it possible to accurately evaluate material damage, even those that are too small to be detected with existing technology. This new technology is expected to improve the safety and reliability of socially important structures such as power generation plants and airplanes, and ultimately, to contribute to the safety of all humans.

**More information:** Yosuke Ishii et al, Finite-element analysis of non-collinear mixing of two lowest-order antisymmetric Rayleigh–Lamb waves, *The Journal of the Acoustical Society of America* (2018). DOI: 10.1121/1.5044422

Provided by Toyohashi University of Technology