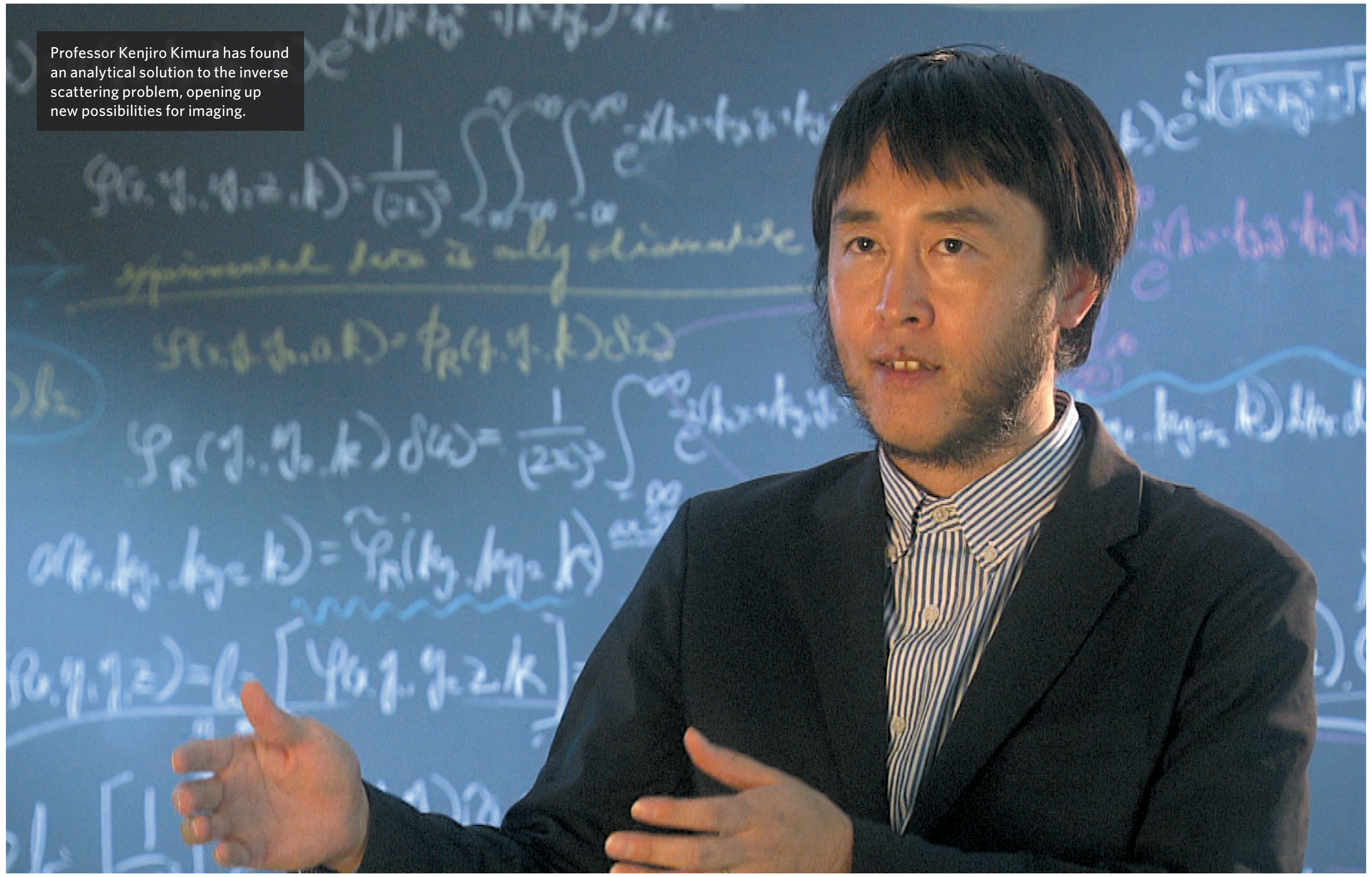
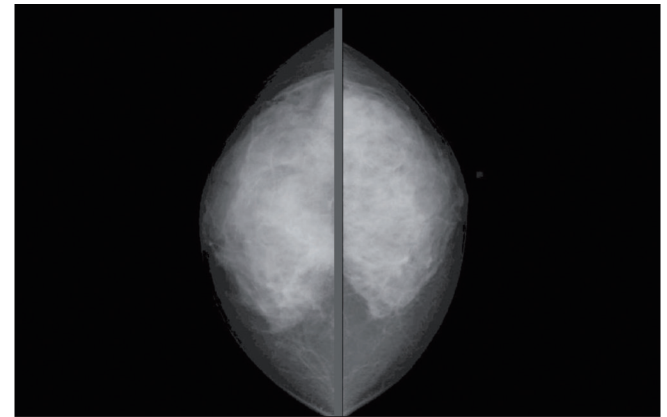
ADVERTISEMENT FEATURE

Discovering a theory to visualize the world

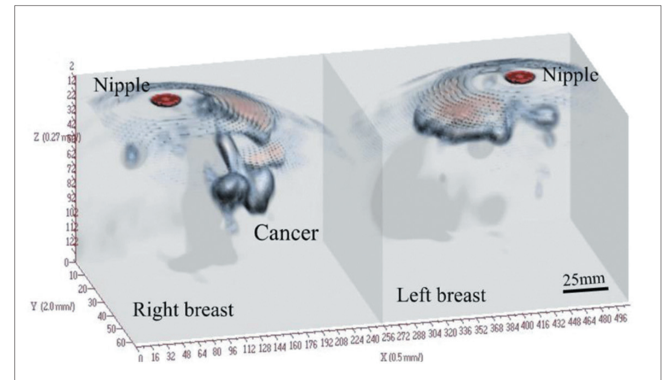
For the first time in the world, THE INVERSE SCATTERING PROBLEM, an unsolved problem in the history of applied mathematics, has been solved analytically



Professor Kenjiro Kimura has found an analytical solution to the inverse scattering problem, opening up new possibilities for imaging.



Conventional X-ray mammography images. It is difficult to distinguish between tumourous and healthy tissue.



Microwave mammography images from the same patient as for the top image. The tumour in the right breast is highly visible.

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X-ray computed tomography (CT) is the conventional core technology for seeing the invisible and seeing through opaque objects. More than 100 years after the invention of X-ray imaging, CT has become widely used in the fields of medicine, non-destructive testing and security. A major premise of CT is that waves are transmitted linearly to the object of interest; therefore, highly transparent radiation or high-energy particle beams, such as X-rays and gamma rays, are used.

THIS RESEARCH THEME WILL LEAD TO THE DEEPENING OF BASIC SCIENCE FIELDS

As a result, it is not suitable in principle for capturing subtle structural differences in the object to be measured. Vice versa, highly scattering, low-energy waves, which respond to subtle structural differences in the object, do not allow the use of the Radon transformation, which is the mathematics of CT based on the assumption of transmission. Therefore, it is necessary to reconstruct the structure of the scattering object by describing the complex phenomenon of wave scattering in a unified manner using a novel mathematical theory. This problem is known as the inverse scattering problem, which had been an unsolved problem in applied mathematics history and for which an effective solution had not been derived, forcing scientists to rely on computationally expensive methods. Recently, a number of research groups have been investigating a model-and-fitting method using ultrafast computers, in which the model and fitting is repeated many times until it converges. Because of the complexity of the objects to be measured, there is no way to extend this methodology, no matter how fast computers are developed in the future.

X-ray imaging developed by Wilhelm Röntgen (who was awarded the Nobel Prize in Physics in 1901), X-ray CT (whose developers were awarded the Nobel Prize in Physiology or Medicine in 1979), positron emission tomography (PET; whose developer was awarded the Gairdner International Prize in 1993) have been used for a long time. However, in order to take the 'see the invisible' mathematics and methodology of the past 100 years to the next stage, it is essential to develop a new theory to organize the complex scattering phenomena caused by objects and waves in terms of higher-level mathematical physics concepts, to solve the inverse scattering problem uniquely, and to reconstruct the structure of the scattered objects.

Professor Kenjiro Kimura and Dr Noriaki Kimura succeeded in solving the inverse scattering problem analytically for the first time in the world in 2012, and have established multi-static scattering field theory. The structure of the scattering field is derived from the fundamental equations of the scattering field derived by Professor K. Kimura and Dr N. Kimura in multi-dimensional space, and the structure of the scattering field is completely determined by setting time and spatial variables to the limit values. The determination of the structure as a solution of the mathematical theory describing complex wave and object interactions in a unified manner is an important historical development in the 'act of looking at objects'.

This progress corresponds to the achievement of a mathematical virtual lens, focusing at every point inside and outside the object, even if the object is shaded, and achieving focus at every point optically. It means that the light is mathematically focused on a region behind the object, which cannot be focused by a real lens. In addition, it allows the most energetically suitable wave to be selected for discrimination, taking into account the physical properties of both the object of interest and the regions of other media. For example, normal and abnormal tissues, which are difficult to distinguish by high-energy radiation, can be visualized in three dimensions with ultrahigh contrast in medical imaging diagnosis, and more accurate image recognition and precise AI judgment can be realized without human intervention. In the field of non-destructive inspection, it will be possible to detect anomalies and defects in the reinforcing bars of concrete structures, which have been impossible to detect at an early stage until now, and to prevent collapses in the event of an earthquake. Furthermore, in the field of automated driving, the system will be able to accurately detect the three-dimensional structure and location of people and obstacles ahead, even in the rain. In geological exploration and planetary exploration, highly accurate structural analysis of the state of materials in the ground and the structure of the Earth's crust will be advanced, which will facilitate an integrated understanding of the Earth's environment and more effective use of natural resources. This research theme will lead to the deepening of basic science fields and the advancement of medical fields and industrial fields, which will lead to a major change in the way we view the world. ■

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