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English translation

NTU Scientists Successfully Prove Quantum Theory for Accurate X-ray Imaging

The continued strengthening of the research bore fruit, NTU scientists proved a quantum theory for accurate X-ray imaging.

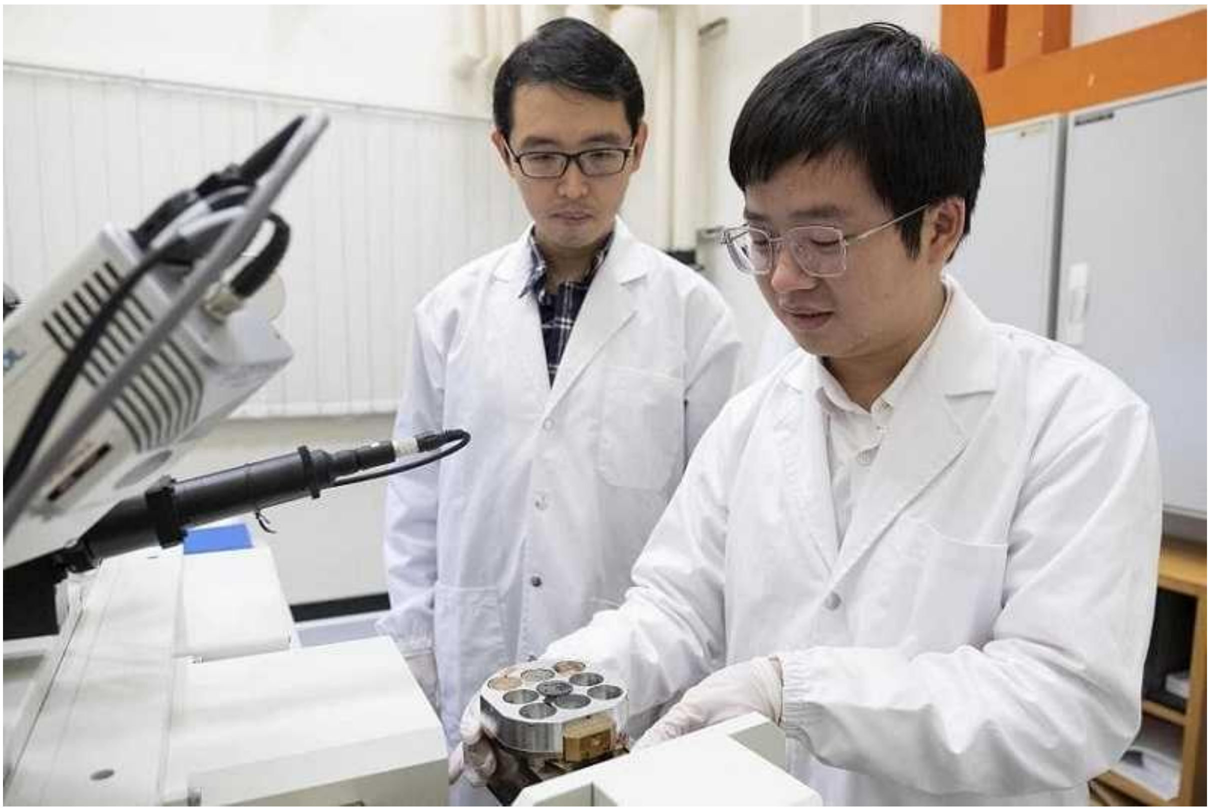

Photo : By courtesy
Researchers from Nanyang Technological University, Wong Liang Jie (left), and co-researcher Huang Sunchao load a sample into a scanning electron microscopy used in their quantum recoil experiments.

SINGAPORE - A team of scientists from Nanyang Technological University (NTU) became the first in the world to successfully demonstrate an 83-year-old theory of quantum physics, in a breakthrough that could pave the way for more accurate X-ray imaging.

As quoted from The Straits Times, Sunday (12/2), the team led by Wong Liang Jie from the School of Electrical and Electronic Engineering, successfully demonstrated in experiments that X-rays are emitted at lower energy levels, as predicted by quantum recoil theory, when charged particles such as electrons pass through a material to produce radiation.

Utilizing quantum recoil, which has eluded scientists for decades, would allow more precise X-ray machines to be developed to image human tissue samples and detect flaws in semiconductor chips.

Radiation such as X-rays can be generated when electrically charged particles such as electrons are accelerated to increase their energy, and pass through a material, interfering with its atoms. When the atom returns to its original state, radiation is emitted.

The Russian physicist Vitaly Ginzburg in 1940 once hypothesized that the radiation energy would be lower than that estimated by classical physics.

This will occur as a result of electrons slowing down and deflecting as they interact with the atoms of the matter they pass through. This phenomenon is known as "quantum recoil".

Classical physics assumes that changes in the energy and pathways of electrons when interacting with atoms are negligible, and thus have an insignificant impact on the resulting radiation energy.

Proving quantum recoil has been frustrating scientists for decades. It requires special materials, such as one that has repeating patterns in its atomic structure, but the precision required to create it is limited by available technology.

The NTU team, which has researched X-ray production by exposing inorganic compounds the size of computer chips to moving electrons, turned their experiments to quantum recoil.

With a scanning electron microscope, they bombarded separate samples of graphite and hexagonal boron nitride (h-BN) with electrons.

The energy of the emitted X-rays was measured and found to match the values predicted by quantum recoil theory.

"It was a happy accident because we were already working with X-rays to develop a more compact way to tune and produce X-rays with different energies for medical, industrial and safety applications," Wong told The Straits Times.

This meant the team was aware of the unique properties of materials such as graphite and h-BN. Graphite is a form of carbon used in pencils, while h-BN is often used to make lubricants in paints.

Both compounds have dense atomic layers in repeating patterns, where each layer is one atom thick.

"We put two and two together and realized that we could use these materials in experiments to demonstrate quantum recoil," he explained.

The team found that quantum recoil and the resulting radiation energy could be modified by tinkering with electron energy, atomic composition, and material tilt angles.

Based on their previous work, the researchers developed a way to allow the same X-ray machine to produce X-rays with specific energy levels to more accurately identify human tissues.

The team is working with Singaporean biomedical equipment manufacturing company CTmetrix to develop a more compact and precise tunable biomedical X-ray machine. They aim to prepare a prototype by the end of 2023.

"We invested in a practical demonstration system, based on the quantum recoil phenomenon, to solve problems in biomedical imaging. When our products are ready, this will support the global bioscience industry in understanding disease and the impact of medical care," said CTmetrix Chief Technology Officer, Edward Morton.

Singaporean company Component Technology also wants to leverage the NTU team's technology to develop an adjustable X-ray inspection machine to check for defects in semiconductor chips such as voids, or air pockets that could lead to chip failure.

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