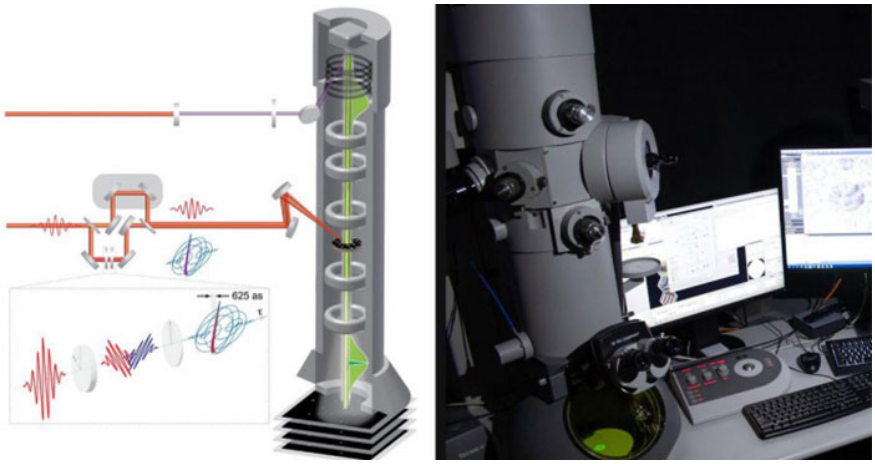
Captured electrons moving at 7,920,000 km/h

A team of physicists at the University of Arizona has developed the world's fastest electron microscope, an upgraded version of the transmission electron microscope that can capture electrons traveling at 7,920,000 km/h.

The new device can capture images of moving electrons by firing electron pulses that last a trillionth of a second. Electrons travel at an incredibly fast speed, about 2,200 km/s or 7,920,000 km/h, and can circle the Earth in just 18.4 seconds.

The team hopes the microscope will lead to new discoveries about how tiny electrons move.



This transmission electron microscope is like a very powerful camera in the latest version of a smartphone, allowing us to take pictures of things we couldn't see before, like electrons, said the study's lead author, Mohammed Hassan, an associate professor of physics and optics at the University of Arizona.

The fact that electrons move so fast has been a major challenge for experts. In the early 2000s, physicists developed a method for generating attosecond (or billionths of a billionth of a second) pulses to create exposure times that could capture the motion of electrons. This research led to the 2023 Nobel Prize in Physics for Pierre Agostini, Ferenc Krausz, and Anne L'Huilliere.

Physicists have reduced microscope exposure times to the scale of a few attoseconds. In doing so, they have deciphered how electrons carry electrical charges, how they behave inside semiconductors and liquid water, and how chemical bonds between atoms are broken. But attoseconds are still too large to capture the individual motions of electrons.

In the new study, the electron gun was modified to produce pulses of just one attosecond. These pulses hit the sample, slowing the electrons as they pass through and changing the shape of the electron beam wavefront. A lens amplifies the slowed-down electron beam, which then hits a fluorescent material. When the electrons hit the material, it glows.

Hassan said the attosecond time resolution of his transmission electron microscope, called 'atto microscopy', allowed scientists to see parts of electrons in motion for the first time. The researchers believe this success will lead to breakthrough advances in physics, chemistry, bioengineering, materials science and many other fields.