Solitary perturbations in the steep boundary of magnetized toroidal plasma

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Researchers have discovered the mechanisms behind reliable nuclear fusion by observing solitary perturbation (SP) structures within microseconds from the onset of the pedestal erosion, suggesting a strong correlation between SP generation and the pedestal collapse. This observation is to provide solid experimental data to identify the governing equations for the mechanisms behind SP generation and pedestal collapse. The SPs in the plasma boundary layer may also provide general interest as a strong nonlinear boundary phenomenon.

The sun is a main sequence star and thus generates its energy by nuclear fusion of hydrogen nuclei into helium. Fusion produces energy many times greater than nuclear fission. As the ramifications of climate change and depleting fossil fuels become clear, scientists all over the world have endeavored to produce a source of clean, sustainable, and plentiful energy. And to this end, nuclear fusion has the potential to meet mankind's need for energy.

The leading candidate for a practical fusion reactor is the tokamak reactor that harnesses the power of the sun here on Earth. It is a magnetic confinement fusion reactor that uses magnetic fields to confine fusion fuel at millions of degrees in plasma form. However, akin to squeezing a balloon until it bursts, the toroidal magnetized plasma constrained within the tokamak develops instabilities along the outer edges. The resulting flux of energy and particles released by the 'burst' or pedestal collapse can severely damage the strike points on the plasma-facing components of the tokamak. Scientists are currently striving to understand and control these crashes as it is a critical issue for the successful operation of the International Thermonuclear Experimental Reactor (ITER) and other future fusion reactors.

Research conducted by Professor Gunsu S. Yun's team and international collaborators has made great contributions to solving this mystery by observing solitary perturbation (SP) structures within microseconds from the onset of the pedestal erosion, suggesting a strong correlation between SP generation and the pedestal collapse. This achievement has been published in the world-renowned *Scientific Reports*.

The team utilized data from the electron cyclotron emission imaging (ECEI) system and the toroidal Mirnov coil array on the KSTAR, or Korea Superconducting Tokamak Advanced Research, and discovered a distinctly different phenomenon than the commonly observed quasi-stable edge-localized filamentary modes (QSMs). The team routinely observed QSMs and their complex structural transitions without crashes on the KSTAR which suggested that QSMs are not directly correlated to the crash.

Professor Yun anticipates that the research team's new observation provides solid experimental data to identify the governing equations for the mechanisms behind SP generation and pedestal collapse. He also anticipates that the SPs in the plasma boundary layer may also provide general interest as a strong nonlinear boundary phenomenon.

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