

Super-computing Sheds Light on Waves in Fusion

Research Researchers at Oak Ridge National Laboratory have recently developed a technique to compute plasma waves across the entire cross-section of a fusion plasma. The new technique does not require any restriction on wavelength or frequency relative to the size of the particle orbits. In this approach, the limit on attainable resolution comes not from the theory itself, but from the size and speed of the available computer required to solve the enormous sets of equations. The new computer program takes advantage of the massively parallel structure of modern super-computers, and has produced the first high definition picture in two dimensions of a process called "mode conversion" in a tokamak (see Fig. 1). In this process, radio waves are injected from the outside of the device. At certain locations, the waves suddenly change character to a different type of wave having very fine scale structure, and are rapidly absorbed by the plasma. The solutions were obtained using 576 separate processors on the latest 1 trillion operation per second IBM RS/6000 SP supercomputer located in the ORNL Center for Computational Sciences. The program achieved speeds of up to 650 billion operations per second.

These calculations are considered to be a breakthrough for wave studies in fusion machines where the short wavelength waves have been associated with a number of important effects besides plasma heating. They can drive electric currents and can force the plasma fluid to flow. They have even been seen to improve the ability of the applied magnetic field to hold the energetic particles and plasma energy inside the device. Until now it has been difficult to get a clear understanding of these phenomena because the modeling capability has been so crude. But the new computer program gives high-resolution pictures which clearly detail the characteristics of the short wavelength structures. The beauty of the new technique is that it is expected to be extendable to much more complicated shapes with intricate, three-dimensional structure that occur in stellarator devices.

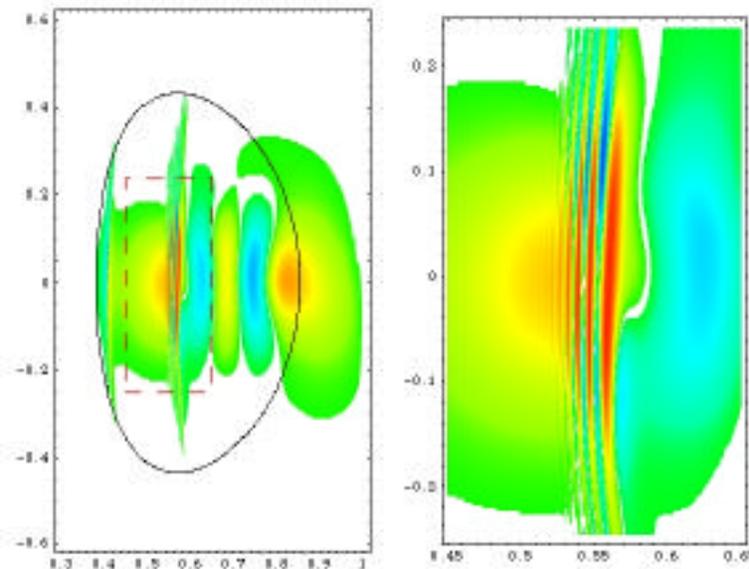


Figure 1. A numerical solution for the wave electric field during mode conversion in a tokamak. On the left, an antenna (in red) launches electromagnetic waves into the plasma. In the region indicated by the dashed box, the wave undergoes a sudden transformation to a very short wavelength structure, called an ion-Bernstein wave, which is absorbed by the plasma within about five cycles. On the right is a blow up of the mode conversion region.

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