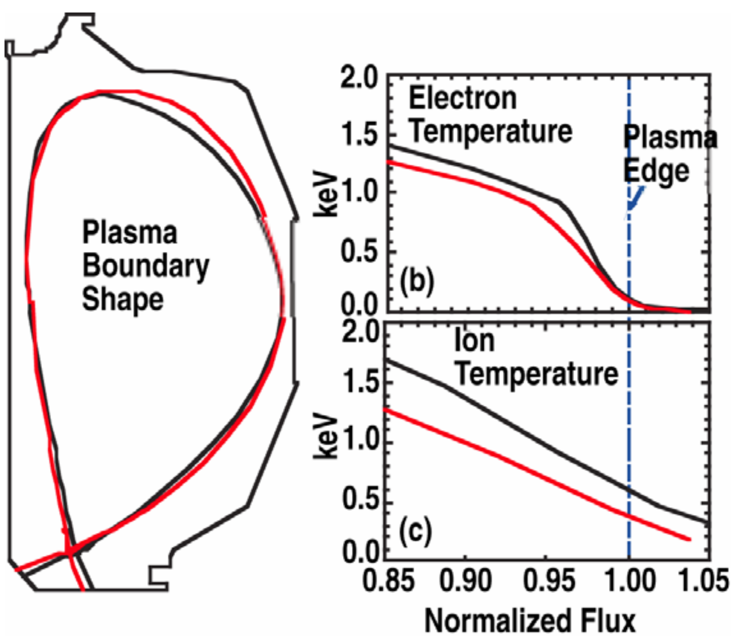
Subtle Changes in Plasma Shape Provides Lift in Fusion Performance

Just as the lift of an airplane's wing is highly sensitive to the shape of the wing, researchers have found that the confinement of energy in a plasma can be increased dramatically by subtle changes in the shape of the plasma. Improvements in confinement are important in achieving the high temperatures, around 100 million degrees C, which are needed for the fusion of hydrogen nucleii to take place. The plasma is heated by beams of high energy neutrals or by microwaves in magnetic fusion systems, and this heating is balanced by heat transport across the magnetic field to the plasma edge, so reducing the heat transport increases the temperature. Most of the heat transport is caused by turbulent eddies within the plasma, researchers agree. Methods to control the transport caused by these eddies have been the subject of many studies, but they have been focused primarily on reducing heat transport well inside the plasma edge.

Researchers at the DIII-D National Fusion facility have shown recently that the confinement of plasma energy can be increased dramatically by making small changes to the shape of the plasma edge, leading to higher temperatures at the edge and throughout the entire plasma. An example is shown in Fig. 1. The small change from the shape of the red curve to the shape of the black curve in Fig. 1a supports the electron and ion temperature increases of Fig. 1(b,c). The temperature increases indicate a 10% increase in plasma confinement. The plasma shape is easily modified through small changes in the currents in coils outside the plasma, so the benefit of increased confinement is obtained virtually cost-free. Further research has also shown that the heat transport actually decreases as the plasma energy increases, suggesting the possibility of "bootstrapping" plasma confinement up to very high levels of energy content.

Knowledge of this approach to improving energy confinement will be valuable in optimizing confinement in present-day devices and in designing effective next-step devices such as ITER that will rely on good heat confinement to generate large amounts of fusion power.



(a) Radial variation of the electron and ion temperature near the plasma boundary for (b),(c) the two different plasma configurations.

Work supported by the U.S. Department of Energy under contract DE-FC02-04ER54698.

Contacts: A.W. Leonard (858) 455-2214, leonard@fusion.gat.com
M.R. Wade, General Atomics (858)455-4165, wade@fusion.gat.com