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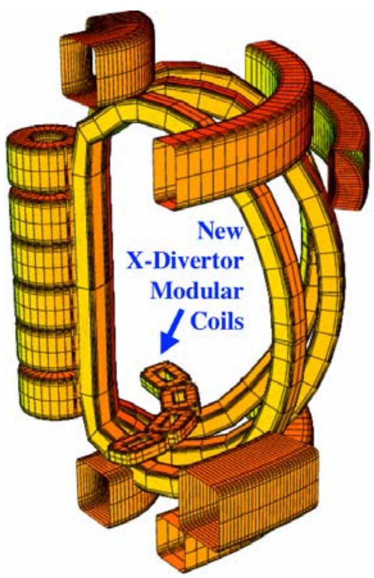
Overcoming High Heat Flux Roadblock to Fusion Energy

Flaring the throat of the "magnetic bottle" removes one of the major roadblocks to fusion power—the safe handling of the huge flow of heat generated in a fusion reactor.

PHILADELPHIA, Pennsylvania, Oct. 30, 2006 – The daunting problem of handling the enormous heat fluxes that a practical and economic thermonuclear fusion reactor will necessarily generate may have been solved through the invention of a new class of magnetic geometries. The new magnetic configurations, called X-divertors, spread the heat flux onto larger areas by flaring the field lines. The flaring enhances the heat-handling capacity of the divertor plate by a factor of five or more. The most crucial step in the conceptual development of the X-divertors was the realization that small, reactor-compatible coils can actually produce the necessary flaring.

It is generally agreed that economically competitive fusion reactors need to be about the same size as ITER (International Thermonuclear Experimental Reactor, to be built in Europe) but must produce about five times higher power. So unless the excess power is somehow radiated away, the standard divertor—already near its limit for ITER—will be destroyed. Unfortunately, even resorting to excessively high radiation cannot save the day: analysis shows that radiating away such high fraction of valuable heating power makes it very hard to keep the plasma hot enough to produce fusion energy. Burning plasmas with such high radiation fractions also tend to be strongly thermally unstable. Neither of these is a reactor option.



The highly enhanced power capacity of the X-divertor can reduce the required radiation to levels where, extrapolating from plasma performance seen in present experiments, sustained fusion power can be produced. The X-divertor has a built-in additional bonus: the main plasma is further isolated from the divertor target plate. Together, these two basic improvements in the "magnetic bottle" critically impact reactor performance.

X-divertors also enable other promising high-heat-flux handling methods, such as the use of liquid metals. In the lower magnetic fields of an X-divertor, liquid metal can flow fast enough to remove heat.

The divertor was singled out as "the most critical component on the way to the reactor" by the former ITER director Paul H. Rebut. A relatively small tokamak at reactor-level power density to test and demonstrate the ability of the X-divertor to handle enormous heat fluxes would be a critical U.S. contribution in our march toward fusion power.

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[UI1.00006] On heat loading, novel divertors, and fusion reactors
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November 2, 2006
Thursday, 12:00 –12:30 pm
Invited Session UI1: Plasma Technology: Magnetic Confinement
Philadelphia Marriott Downtown - Grand Salon ABF

Further information
M. T. Kotschenreuther, P. Valanju, S. M. Mahajan, and J. C. Wiley, “On heat loading, novel divertors, and fusion reactors,” to be published in *Physics of Plasmas* (2006).