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PROGRESS TOWARD UNITY BETA PLASMAS IN ELECRIC TOKAMAK*

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The UCLA Electric Tokamak (ET) has been designed and constructed to explore the possibility of operating high aspect ratio tokamaks well beyond the first stability (Troyon) limit using plasma rotation to improve confinement and stability. It is a sub-ITER sized device with R=5 m, a=1 m, b = 1.5 m. The confinement time at densities well below the Murakami limit (n $<10^{20}$B/R) is limited by anomalous electron losses, as in the well known neo-Alcator regimes. In this respect ET is not different from the Alcator-A device provided that proper scaling of fields and currents is taken into account. Confinement times well over 200 msec have been reached, with T(0) ~ 200 eV, at 50 kA currents. This performance is somewhat better than the best predictions, and ET provides us with excellent target plasmas for ICRF heating and non inductive current drive. The device is shown in Figure 1.

Achieving the goal of equilibrating near unity beta plasmas will require 10 second long discharges (at T = 3 kV, B = 0.25 T) due to current diffusion limitations. Our calculations indicate that non-inductive current profile control needs to be achieved even before we can attempt to pass beyond the Troyon limit. In order to do this, a series of ICRF experiments has been performed to first heat the ion and electron species. Both low power wave absorption studies and high power heating show that good single pass absorption can be achieved in the ion-ion hybrid regimes for electron heating and current drive. Also, good ion heating is possible at the second harmonic frequency of the majority ions.

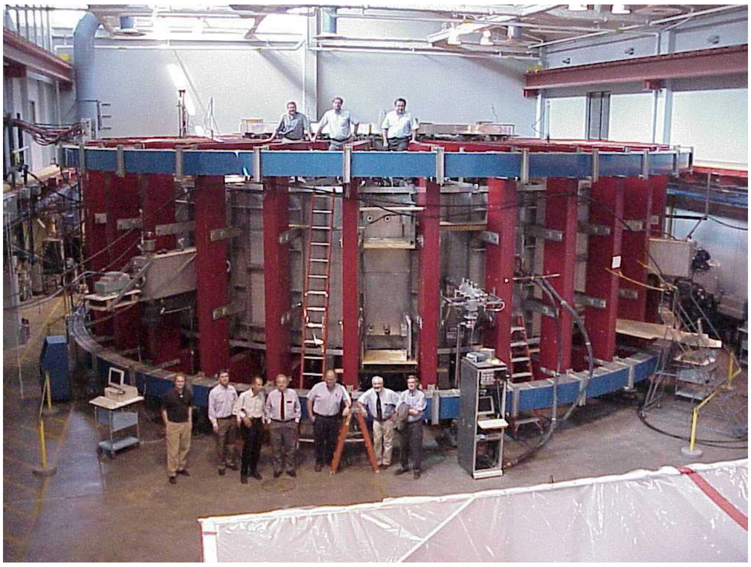

Figure 1 The ET tokamak August 2000.

Due to the excellent heat confinement and

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the relatively low power density required for heating, no density bump has been seen. In fact, ET has been designed to explore ICRF heating and current drive and fast ion stabilization (through rotation). About 50% of its 200 m^2 plasma surface area has been reserved for antenna access. At present only single antenna excitation has been tested with surfaces not exceeding 2 m^2, with a factor two increase in plasma temperature. So far, textbook-like results have been obtained in all respects related to ICRF behavior.

The discharges are feedback controlled in up/down position and in plasma current. Biased electrode driven H-modes have been obtained and compare well with the results obtained on CCT by Taylor(1) and agree with the "neoclassical bifurcation" theory of Shaing.(2)

ET 's major goal is to explore the stability and confinement of unity beta plasmas. Asymptotic theory of Cowley(3) for high beta equilibrium has been numerically augmented by results from community code studies (NIMROD and DCON). The numerical studies point to on creating non-inductive current profiles in tokamaks in order to move away from the limitations of 35 year old ohmic tokamak experience. To explore the departure we have started out at low toroidal fields. At this time the results indicate that we will be able to achieve all our unity beta parameter goals at 0.25 Tesla toroidal field as planned. Then at 1 Tesla fields, near ignition conditions can be reached if omnigenous magnetic conditions of Palumbo(4) are obtainable near unity beta. The omnigenous magnetic conditions are shown in Figure 2 and are expected to confine plasma classically. The resulting configurations are expected to be close to the diffusion driven current configurations studied by Jensen(5) and could extend to reverse field configurations in a tokamak where stabilization is assisted by plasma rotation.

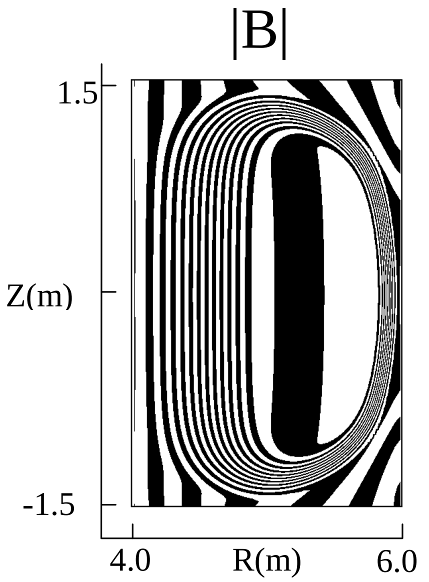

Figure 2. Closed ModB surfaces near unity beta.

A low cost reactor path to large tokamaks will be presented.

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