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Micro- and Macro-Instability, and Large Density and Beta in Improved Confinement MST RFP Plasmas

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In MST plasmas where inductive current profile control routinely produces tokamak-like confinement with enhanced density and temperature gradients, a far-forward-collective-scattering diagnostic reveals a broad-band reduction of density fluctuations, with as much as a 100-fold drop in amplitude. This drop is precipitated largely by the reduction of current-gradient-driven tearing modes. However, in the region where thermal gradients are largest, there is a localized peak in the density fluctuation power spectrum. The source of these fluctuations is not established, but gyrokinetic modeling with the GENE code suggests the trapped electron mode, driven by the local density gradient. These plasmas, whose density is well below the Greenwald limit, routinely exhibit a large total beta (average plasma pressure normalized to the total edge field pressure) of about 15 percent, but this beta is limited only by the finite Ohmic heating power. With the goal of trying to establish the limits on density and beta in these plasmas, frozen deuterium pellets were injected to increase the density and the Ohmic heating power. This has resulted in an RFP-record density of 1.6 times the Greenwald limit, but the upper limit on the density in these plasmas still has yet to be established. Over a broad range of density, from well below to well above the Greenwald limit, the total beta is routinely enhanced. And now, with the addition of NBI, the total beta has reached an RFP record of about 28 percent (with toroidal beta ~ 115 percent), and it appears that this represents a soft limit on beta. Magnetic fluctuations increase as the density increases, leading to increased energy transport, and these discharges do not exhibit premature terminations. According to MHD modeling with the NIMROD code, both pressure-driven tearing and interchange modes can be linearly unstable in these plasmas, unlike the discharges at lower beta. These instabilities can contribute to the enhancement of magnetic fluctuations. This soft beta limit phenomenology is similar to that observed in some stellarators.

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