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Natural Fueling of the Core and Edge in a Tokamak Fusion Reactor[1]

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A natural fueling mechanism[2] that helps to maintain the main core deuterium and tritium (DT) density profiles in a tokamak fusion reactor is presented. In H-mode plasmas dominated by ion-temperature gradient (ITG) driven turbulence, cold DT ions near the edge will naturally pinch radially inward towards the core. This mechanism is due to the quasi-neutral heat flux dominated nature of ITG turbulence and still applies when trapped and passing kinetic electron effects are included. Fueling using shallow pellet injection or supersonic gas jets is augmented by an inward pinch of could DT fuel. The natural fueling mechanism is investigated using the gyrokinetic turbulence code GEM and is analyzed using quasilinear theory. Profiles similar to those used for conservative ITER transport modeling that have a completely flat density profile are examined and it is found that natural fueling actually reduces the linear growth rates and energy transport. Additionally, it is shown that the Helium ash diffuses radially outward as the cold fuel moves radially inward. The natural fueling effect may also apply to the edge pedestal density buildup. Recent DEGAS 2 calculations indicate the neutrals in the pedestal are colder than the background ions.[3] We intend to do further work to determine what cold fuel profiles are needed to fuel the pedestal and if they are consistent with edge neutral source models. Natural fueling (either in the core or edge) requires a two component (hot bulk and cold fuel) plasma and charge exchange collisions tend to equilibrate the ion and neutral source temperature reducing the effect. We will further investigate the relevant collisional time scales and further demonstrate the viability of the natural fueling mechanism for ITER parameters.

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[2]W. Wan, S. E. Parker, Y. Chen and F. W. Perkins, Phys. Plasmas **17**, 040701 (2010).

[3]D. Stotler, International Transport Task Force Meeting, Annapolis, MD (2010).