Progress on FY2008 Third Quarter Milestone

The third quarterly milestone for the FY2008 JOULE Theory Milestone states that MIT shall "T*est scaling of the TORIC-LH solver for resolutions greater than 1023 poloidal modes with the number of radial elements fixed at1000 for the Alcator C-Mod test case."* This milestone was accomplished by carrying the simulations summarized in the table below on the Loki computing cluster at the MIT Plasma Science and Fusion Center.

Processor Cores	Radial Elements - N_r	Poloidal Modes - N_m	Wall Clock Hours	CPU Hours
256	980	1023	5.6	1434
256	980	2047	39	9984

It can be seen from these results that as the number of poloidal modes (N_m) was doubled from 1023 to 2047, the required wall clock and total CPU hours increased by a factor of 7 (seven) at fixed processor number. The primary algorithmic operation in the TORIC-LH solver is one of matrix inversion which scales as N_m^3, thus the expected CPU requirement should increase by a factor 8 (eight). The slightly better than expected scaling occurs because a small part of the TORIC-LH algorithm involves power reconstruction which only requires N_m^2 operations.

The parameters used in these simulations are characteristic of LHRF experiments in the Alcator C-Mod device at MIT with $B_0 = 5.4$ T, $n_e(0) = 7 \times 10^{19}$ m^{-3}, $T_e(0) = 2.2$ keV, and $f_0 = 4.6$ GHz. Spectral plots of the fast Fourier transform (FFT) of the parallel electric field of the wave versus poloidal mode number, plotted on different flux surfaces demonstrate that the solution is fully converged at 2047 poloidal modes. These new results were published in a paper entitled *"Full wave simulations of lower hybrid waves in toroidal geometry with non-Maxwellian electrons"*, by J. C. Wright, E. J. Valeo, C. K. Phillips, P. T. Bonoli, Communications in Computer Physics **4**, 545 (2008).

During the third quarter we also started to carry out verification studies to confirm that the physics kernel of the LH full-wave solver is behaving properly. This consisted of scanning the thermal electron temperature in order to confirm that the spatial location of the wave absorption changed as expected. The background electron density was also varied in order to study physical effects related to wavelength variation such as focusing and diffraction. Finally, we began to carry out comparisons between the absorption and propagation predicted by the full-wave solver and a torodial ray tracing treatment. The primary focus of the fourth quarter activity will be to continue verification studies and compare simulation predictions with LHRF experimental results from Alcator C-Mod.