Impact of First-Principles Properties of Deuterium–Tritium on Inertial Confinement Fusion Target Designs: A comprehensive knowledge of the properties of high-energy-density plasmas is crucial to understanding and designing low-adiabat, inertial confinement fusion (ICF) implosions. Warm-dense-matter (WDM) conditions are routinely accessed by low-adiabat ICF implosions, in which strong coupling and electron degeneracy often play an important role in determining the properties of warm dense plasmas. The WDM properties of deuterium–tritium (DT) mixtures and ablator materials, such as the equation of state (EOS), thermal conductivity, opacity, and stopping power were usually estimated in hydrocodes by models used for ICF simulations. In these models, many-body and quantum effects were only approximately taken into account in the WMD regime. Moreover, there was often no self-consistency among these models. To examine the accuracy of these models, we have systematically calculated the static, transport, and optical properties of warm dense DT plasmas, using first-principles (FP) methods over a wide range of densities and temperatures that cover the ICF "path" to ignition. These FP methods include path-integral Monte Carlo (PIMC)[1] and quantum-molecular dynamics (QMD)[2] simulations, which treat electrons with many-body quantum theory. The first-principles equation-of-state (FPEOS) table,[1,2] thermal conductivities[3] (κ_{QMD}), and first-principles opacity table[4] (FPOT) of DT have been self-consistently derived from the combined PIMC and QMD calculations. The FP-derived properties of DT can have significant differences from the traditional models of *SESAME*-EOS, the Lee–More thermal conductivity, and the cold-opacity–patched Astrophysics Opacity Table (AOT).

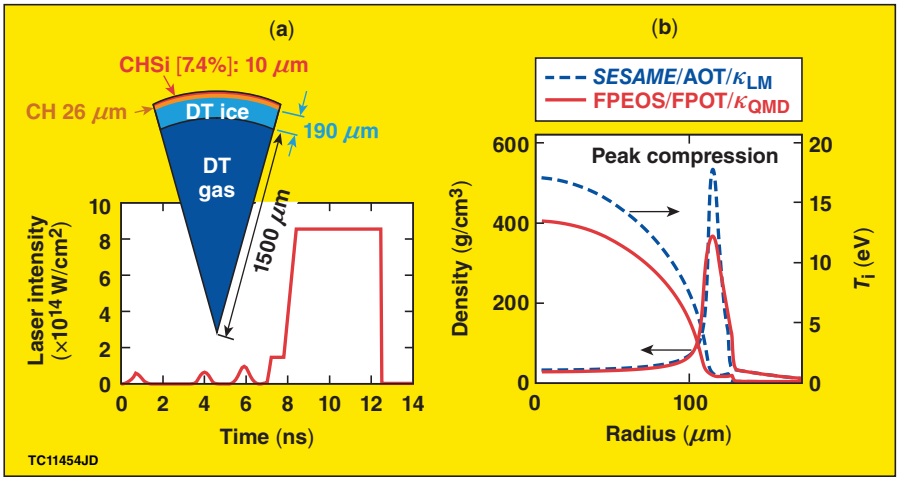

Figure 1. (a) The model-predicted pulse shape for a direct-drive, low-adiabat ($\alpha \approx 2$) ignition design for the National Ignition Facility (NIF), where the insert is the schematic diagram of the NIF target; (b) comparisons between the traditional model prediction (blue curves) and the simulation using the first-principles (FP)–calculated properties of DT (red curves), in which the density and ion temperature are plotted as a function of radius at peak compression.

These FP-based properties of DT have been implemented in LLE's hydrocodes (*LILAC* and *DRACO*), and their effects on ICF implosions examined through comparisons with the traditional model simulations. We found that the predictions of ICF neutron yield (energy gain) could change by up to a factor of ~2.5; the lower the adiabat of DT capsules, the more variations in hydro simulations. Figure 1 shows the hydro simulation comparisons for a direct-drive National Ignition Facility (NIF) target design of adiabat $\alpha \approx 2$. Figure 1(a) indicates the target and the pulse shape, while Fig. 1(b) illustrates the density and ion-temperature comparisons near the peak compression. Comparing with the traditional model simulation, the FP-based simulation reduces the target gain from $G = 40$ to $G = 23$. This change is attributed to the adiabat increase as a result of the different compressibility (EOS), enhanced thermal conduction, and radiation preheat with using the FP-calculated properties of DT. The reduction of target gain can be recovered by using these FP-based properties of DT to retune the laser pulse shape. Work on FP studies of ICF ablator materials is underway. This work was done in collaboration with the T-1 group at LANL and the University of California, Berkeley.

Omega Facility Operations Summary: The Omega Facility conducted 220 target shots in October with an average experimental effectiveness of 94.5% (147 on OMEGA and 73 on OMEGA EP with experimental effectiveness of 93.2% and 97.3%, respectively). The ICF program accounted for 138 shots taken for LANL, LLNL, and LLE, while the HED campaign had 66 shots taken for LLNL and LLE-led experiments. One NLUF experiment led by Rice University had 11 shots and one LLNL LBS experiment received 7 target shots.

1. S. X. Hu *et al.*, Phys. Rev. Lett. **104**, 235003 (2010).
2. S. X. Hu *et al.*, Phys. Rev. B **84**, 224109 (2011).
3. S. X. Hu *et al.*, Phys. Rev. E **89**, 043105 (2014).
4. S. X. Hu *et al.*, Phys. Rev. E **90**, 033111 (2014).