The Parameter Space for MIF

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MTF is subset of MIF

-- it appears to be possible over a large range of target-plasma sizes, densities, magnetic fields, etc., but in terms of parameter space, the combinations of these quantities are fairly well defined.

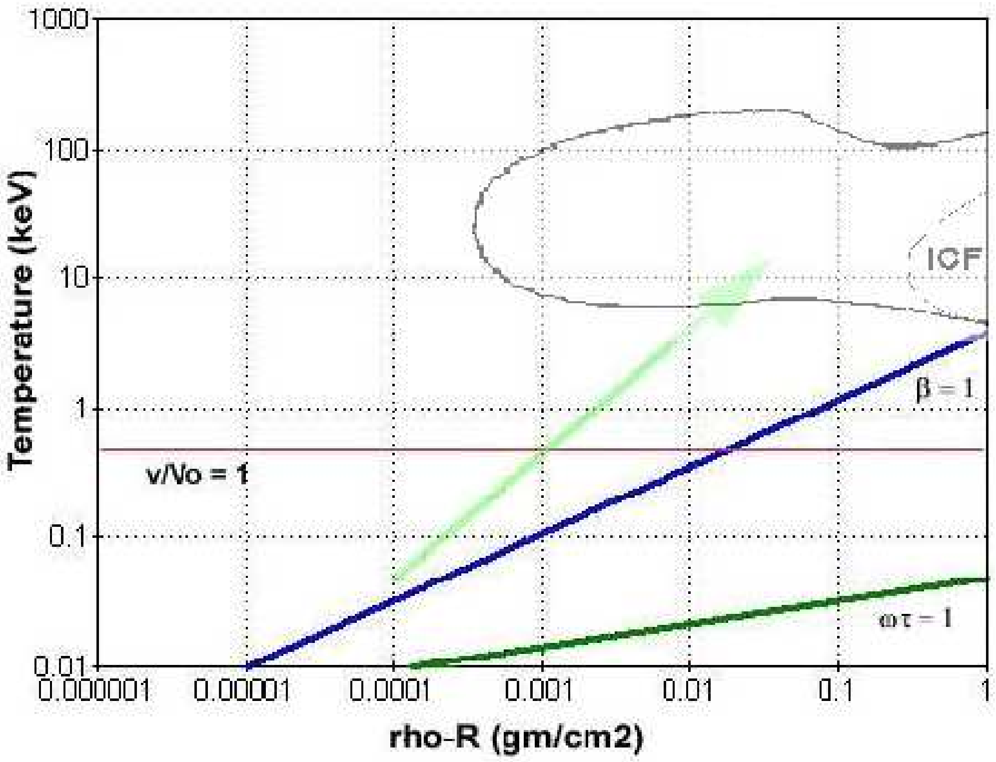

Figure 1. ICF parameter space presented via Lindl-Widner (L-W) diagrams for the special case of a uniform Bθ field. Note that the presence of a magnetic field expands the parameter space.

SIMILARITIES & DIFFERENCES BETWEEN MTF & IFE

Both IFE and MTF rely on compression of a warm dense plasma to fusion temperatures, but MTF uses a magnetic field.

However, MTF ignition can occur at a much lower pressure times radius parameter (PR) than what is needed for IFE.

Therefore, a much lower compression rate is suffices for ignition.

Unlike IFE, the L-W diagram for MTF depends
on the mass of the target plasma.

As the mass of the target decreases,
the area where ignition can occur shrinks.

Also, as the field strength decreases, the area shrinks.

COMPRESSION TO IGNITION

In Figure 1, the green arrow represents compression along an adiabat
from about 50 keV, 100 kG and 0.0001 gm/cm2.

If the energy supplied by a liner allows leads to high enough PR,
then the target plasma should ignite.

For too low DT mass, the fusion ignition area may shrinks too much to allow ignition,
so that one may be forced to operate in a non-ignition mode.

For sufficiently fast compression (v > 0.5 cm/μs),
the temperature history should be close to that of adiabatic compression
followed by adiabatic expansion after the liner stagnates if ignition fails.

LINDL-WIDNER DIAGRAMS and SELF-HEATING

The Lindl-Widner diagrams presented here are based on the assumptions of uniform density and temperature in the target plasma as well as a uniform distribution of the fusion energy deposition. A particle tracking code was used to calculate the fraction of fusion energy deposited within the spherical volume. Then an empirical scaling law for $\mathbf{f_\alpha}$ as a function of ρ**R** and the field times radius parameter **BR**.

An analysis is currently under way to provide a more better scaling law. However, the above survey results are insufficient for the design of an MTF target. In particular, the exact distribution of the deposited fusion energy is needed for design calculations. While Fokker-Planck and multi-group diffusion seem to suffice for energetic particle energy deposition in IFE targets, this is not the case for MTF. We have used particle tracking to get $\mathbf{f_\alpha}$ for the above L-W diagrams, and it can supply a more exact distribution of the deposited fusion energy within the target. However, this method is very expensive for the high BR case. Another approach that may suffice for both efficient and accurate calculations of a dynamic burn process may be compared to the use of equations of state (EOS) treatment of material properties, i.e.. pre-calculation of appropriate transport coefficients.

FIELD GRADIENTS IN THE PLASMA

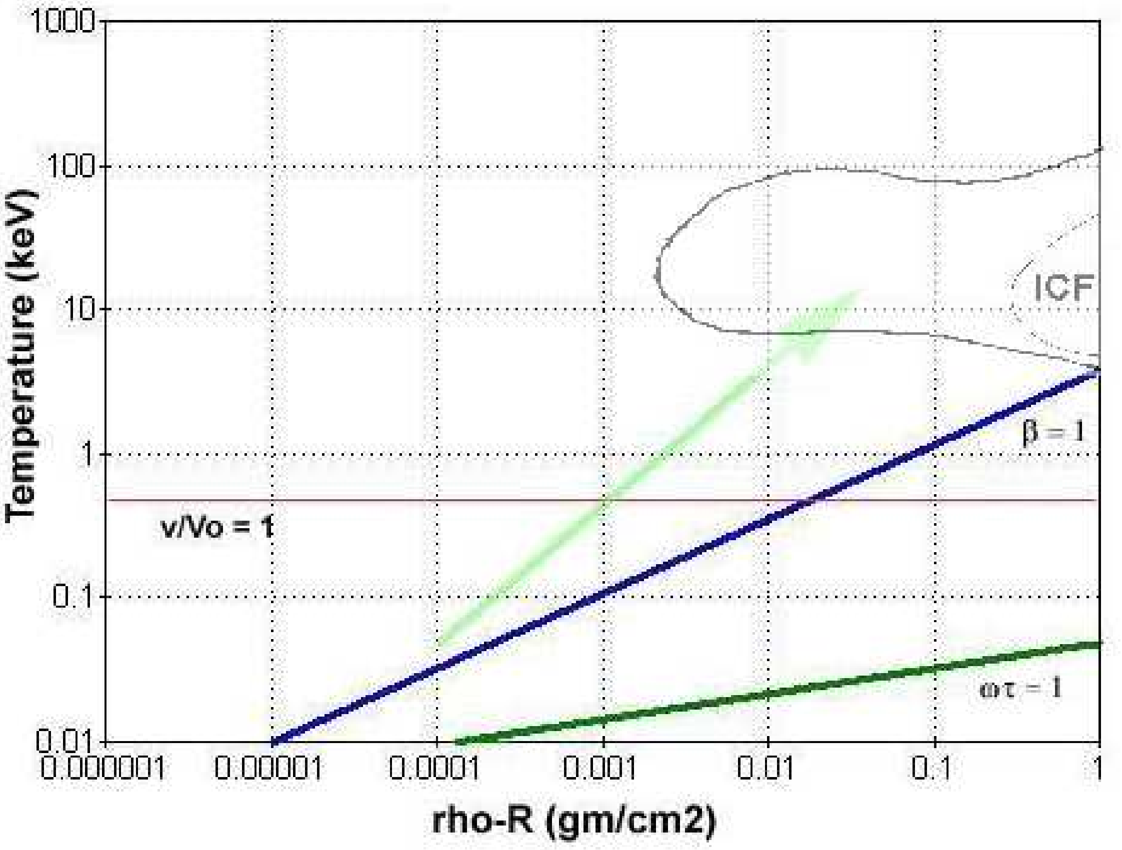

Figure 2. L-W diagram for the case of a field gradient generated by an on-axis current (B ~.BR/r) in the target plasma.

BEYOND FUSION IGNITION

For a practical fusion energy system, it is necessary to get significant fusion gain.

For a non-ignition mode of operation, the temperature and density histories reflect the adiabatic compression/decompression and it is easy to determine the gain of the target.

However, in an ignition mode of operation the temperature history is depends on the energy balance within the target, but generally leads to a considerably higher gain.

There has long been a misconception propagated by a particularly simple relation derived by Moses and Duderstadt. It was based on the early idea of igniting a bare droplet of DT, which then burned briefly at a constant temperature while disassembling.

Current IFE targets are structured and the disassembly is slower, plus the temperature history is an important determining factor for gain as well as disassembly.

Another important aspect of target performance is ignition of a cold fuel layer. While this has been shown to be possible for MTF, it does have limitations.

The major need in current MIF/MTF research is a detailed design code calculation coupled with a sufficiently predictive survey of the parameter space for MIF/MTF. Both the design codes survey codes currently have significant deficiencies.

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