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Theoretical Studies of Non-thermal Fusion Gain

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Thermal fusion has been extensively studied, and the fusion gain can be determined by the Lawson criteria, which utilizes formulas for thermal fusion reactivity and radiation loss. However, recent experiments at JET and NIF have observed non-Maxwellian fusion phenomena, attracting growing attention for advanced fuel fusion.

We have conducted a series [1-8] of research related to non-thermal fusion, including:

(1) Deriving an analytical formula [2] for the fusion reactivity of drift bi-Maxwellian ions. This result is used to investigate the potential enhancement of fusion reactivity due to the combination of beam and temperature anisotropies. For relevant fusion energy parameters, the enhancement factor can exceed 20%, which is particularly significant for proton-boron (p-B11) fusion, as this factor can have a substantial impact on the Lawson fusion gain criteria.

(2) Numerically studying [3,4,5] the enhancement of fusion reactivity under non-Maxwellian distributions, including drift-ring-beam, slowing-down, and kappa super-thermal distributions. And also gives the upper bound of non-thermal fusion reactivity with fixed total energy, which is found to be with several beams.

(3) Revisiting [8] the electron-ion and electron-electron bremsstrahlung radiation power in fusion plasmas and proposing more accurate analytical fitting methods for both non-relativistic and relativistic energy ranges.

(4) Exploring potential development pathways for advanced fuel fusion energy [1,6,7].

These works provide an important theoretical foundation for deeper understanding and optimization of non-thermal fusion processes.

References

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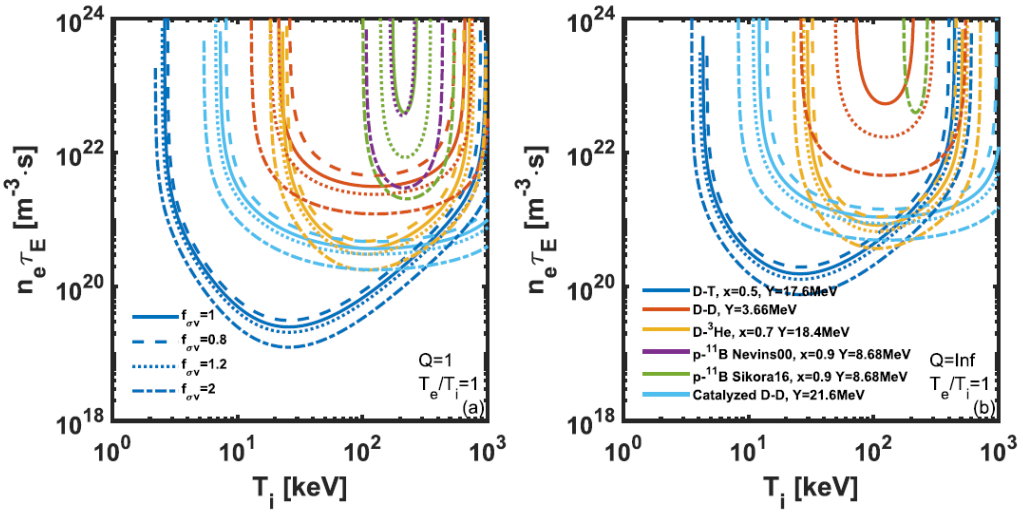

Figure 1. The effect of varying the fusion reactivity enhancement factor, f⟨σv⟩, with values of 0.8, 1.0, 1.2, and 2.0, on the Lawson criteria of D–T, D–D, D–He3, p–B11, and catalyzed D–D fusions is shown for the cases of Q=1 (left) and Q = ∞ (right), with the assumption of equal electron and ion temperatures, Te = Ti. Note that some p–B11 lines may be invisible in the figure.