Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Highly enhanced flame propagation by turbulence through differential diffusion SHENG YANG, ABHISHEK SAHA, FUJIA WU, CHUNG LAW, Princeton University — Turbulent flame speed is an essential parameter in turbulent combustion. The existence of turbulence significantly enhances the flame speed of a premixture, mainly through the increase in the total flame surface area and modification of the flame structure. As of now, the highest turbulent flame speed reported is around 35 times those of the laminar flames, and there is no consensus if this is the upper limit or even if there exists one. In the present experimental work, we report highly enhanced turbulent flame propagation, with the ratio of turbulent flame speed to laminar flame speed reaching 200. Moreover, we demonstrated that such enhancements occur for extremely weak mixtures, whose adiabatic flame temperatures are lower than 900 K and are commonly believed to be beyond the flammability of sustained one-dimensional laminar flame propagation. We further identified that such a strong enhancement effect occurs for mixtures with either extremely small Lewis number or large mass diffusivity of the deficient reactant and that such flames exhibit different morphology from previously observed turbulent flames, as finger-shape structures are developed on the flame fronts and local extinction and re-ignition are frequently observed. This work demonstrates the extension of flammability limit by turbulence and differential diffusion, enabling sustained flame propagation with extremely low burnt gas temperature (<1000 K), and the highest flame speed enhancement by turbulence so far.

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Date submitted: 31 Jul 2015 Electronic form version 1.4