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燃料過濃条件における Flame ball の存在可能性に関する数値的検討

Numerical study on existence of flame ball under fuel-rich condition.

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Understandings the combustion limit and near-limit flame dynamics in low-Lewis-number mixtures are of fundamental and practical importance. There is a unique type of unconventional flame observed in quiescent low-Lewis-number premixture under microgravity, called flame ball that is steady, spherical, and non-propagating nature. Flame ball was suggested by Zel'dovich [1] and then the existence has been confirmed experimentally in drop tower experiments [2,3] and in space experiment [4]. Flame ball was observed even under lower equivalence ratio condition than the flammability limit of conventional propagating flames. Conventional flame and flame ball have been separately investigated due to the

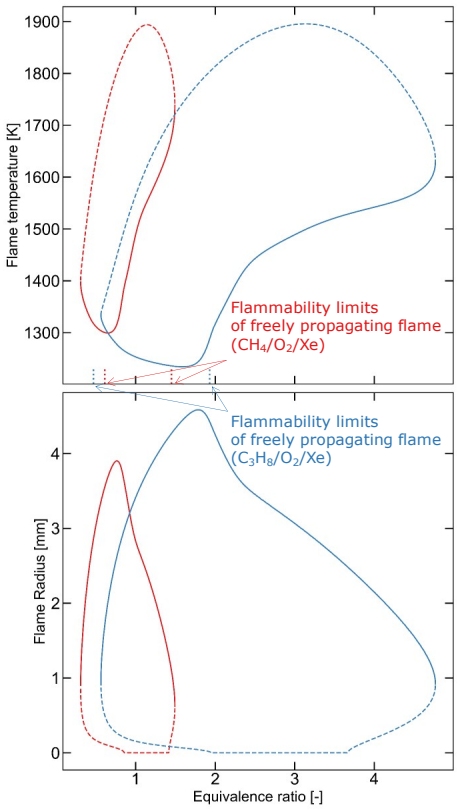

Fig. 1 Flame temperature and flame radius of flame balls in $CH_4/O_2/Xe$ mixture (red curves), in $C_3H_8/O_2/Xe$ mixture (blue curves), and flammability limit of freely propagating flame (dotted vertical lines).

difference of their nature with and without propagation. We have studied behaviors of low-speed counterflow flame under parabolic-flight microgravity condition to investigate these two flames in the same configuration. In such conditions, the formation of multiple ball-like flames [5] was confirmed. For further investigation, space experiment in Japanese module of ISS "Kibo" is scheduled in 2022FY. Various studies on fuel-lean combustion limit were conducted. However, knowledge on fuel-rich condition is still limited. Therefore, the existence of flame ball under fuel-rich condition is still unknown. If flame ball also exists under fuel-rich condition, this helps understanding of the combustion limits and the nature of flame ball.

To investigate the existence of flame ball under both fuel-rich and fuel-lean conditions, one-dimensional steady computation [6] with detailed chemistry was conducted. The converged solutions were obtained even under fuel-rich conditions as shown in figure 1. Flame ball exists under fuel-leaner (fuel-richer) condition than fuel-lean (fuel-rich) limit of freely propagating flame except under fuel-lean condition of $C_3H_8/O_2/Xe$ mixture. We introduce the extinction mechanism of flame ball and the unique behavior of deficient reactant switching [7,8] in flame ball in this presentation.

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