Stable Weak Detonations based on Supersonic Autoignitive Reaction Wave Concept

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Abstracts

Weak detonations represent one of combustion physics' most enduring paradoxes—mathematically predicted by classical theory yet considered fundamentally unstable, with experimental verification limited to specialized chemical systems like H_2-Cl_2 mixtures [1]. This study resolves this long-standing contradiction by demonstrating that weak detonations can exist as stable phenomena through supersonic autoignitive reaction waves [2]. These reaction waves form when inflow velocity exceeds the Chapman-Jouguet detonation speed, creating structures governed purely by chemical kinetics with negligible transport effects. Remarkably, supersonic autoignitive reaction waves exhibit identical flow characteristics to theoretically predicted weak detonations. We prove that the governing equations for autoignitive reaction waves are mathematically equivalent to classical Rayleigh flow [3], providing the theoretical foundation for stable weak detonation existence. This equivalence reveals a fundamental Legendre transformation relationship between energy conservation and chemical reaction progress. Unlike previous approaches limited to specialized kinetics, our unified theory enables stable weak detonation formation under general chemical conditions. This breakthrough resolves the classical weak detonation instability paradox and provides new insights for supersonic combustion applications and astrophysical detonation phenomena.

References

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