A comprehensive analysis of flow structure in a channel with cavity

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The present study delves into the numerical analysis of supersonic flow within a cavity-equipped channel, emphasizing the examination of oscillation spectra using fast Fourier transform. The resulting periodic self-oscillatory regime reveals two distinct modes: acoustic vibrations driven by sound wave propagation along the cavity, calculated via the modified Rossiter formula, and flow-rate oscillations stemming from mass transfer between the cavity and external flow. Injection fuel before the cavity modifies the flow structure, initiating active combustion in the fuel–air mixing layer and triggering Kelvin–Helmholtz instability at the interface between the primary flow and reacted gas. Notably, an increase in supplied fuel pressure induces a decrease in oscillation frequency and an augmentation in the characteristic size of oscillations. This comprehensive exploration sheds light on the intricate interplay of flow dynamics, combustion processes, and external influences, offering valuable insights for optimizing combustion systems in practical applications. Comparative analysis with alternative models and alignment with existing experimental data further validate the robustness and relevance of our findings