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Dynamics of a Reactive Falling Film at Large Peclet Numbers

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We study the dynamics of a vertically falling film in the presence of a first-order (exothermic or endothermic) chemical reaction. Our analysis is based on a long-wave expansion (LWE) and an integral-boundary-layer (IBL) approximation of the equations of motion, energy/concentration and associated free-surface boundary conditions. We also develop a hierarchy of IBL models starting from a simplified Shkadov approach to large IBL systems based on high-order Galerkin projections. Particular emphasis is given to permanent-form solitary waves. We contrast the solitary wave solution branches obtained from LWE and IBL and we show that LWE leads to branch multiplicity and limit points while IBL predicts the continuing existence of solitary pulses for all Reynolds numbers. We also demonstrate that for large Peclet numbers the inclusion of the heat/mass transport convective effects can make the solitary waves dispersive. For large dispersion and for a sufficiently large region of Reynolds numbers, the liquid layer can be excited in the form of non-dissipative solitary pulses which close to criticality assume the form of KdV solitons.

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