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Renormalization group analysis of randomly growing surface with active feedback on incompressible fluid

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Stochastic dynamics of a scalar field evolving according to the nonlinear Kardar–Parisi–Zhang (KPZ) equation and interacting with a randomly moving incompressible fluid is investigated. The fluid dynamics is described by the stochastic Navier–Stokes equation with an external random force. In a difference with previous studies, an active feedback reaction of the growing surface profile on the fluid velocity field is included. The analysis is performed within the field-theoretic approach and Renormalization Group (RG) framework. Renormalization constants, β -functions, and anomalous dimensions are calculated in the one-loop approximation using dimensional regularization and Minimal Subtraction (MS) scheme. Fixed points of the RG equations are found, and their infrared (IR) stability is examined via eigenvalues of the stability matrix. The main physical result is that at the only IR-attractive fixed point, the coupling constant corresponding to the active feedback of the scalar field on the fluid vanishes. This means that at macroscopic spatial and temporal scales, turbulent mixing dominates and suppresses the hydrodynamic response induced by the growing surface.

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