Transition to turbulence in a heated non-Newtonian pipe flow

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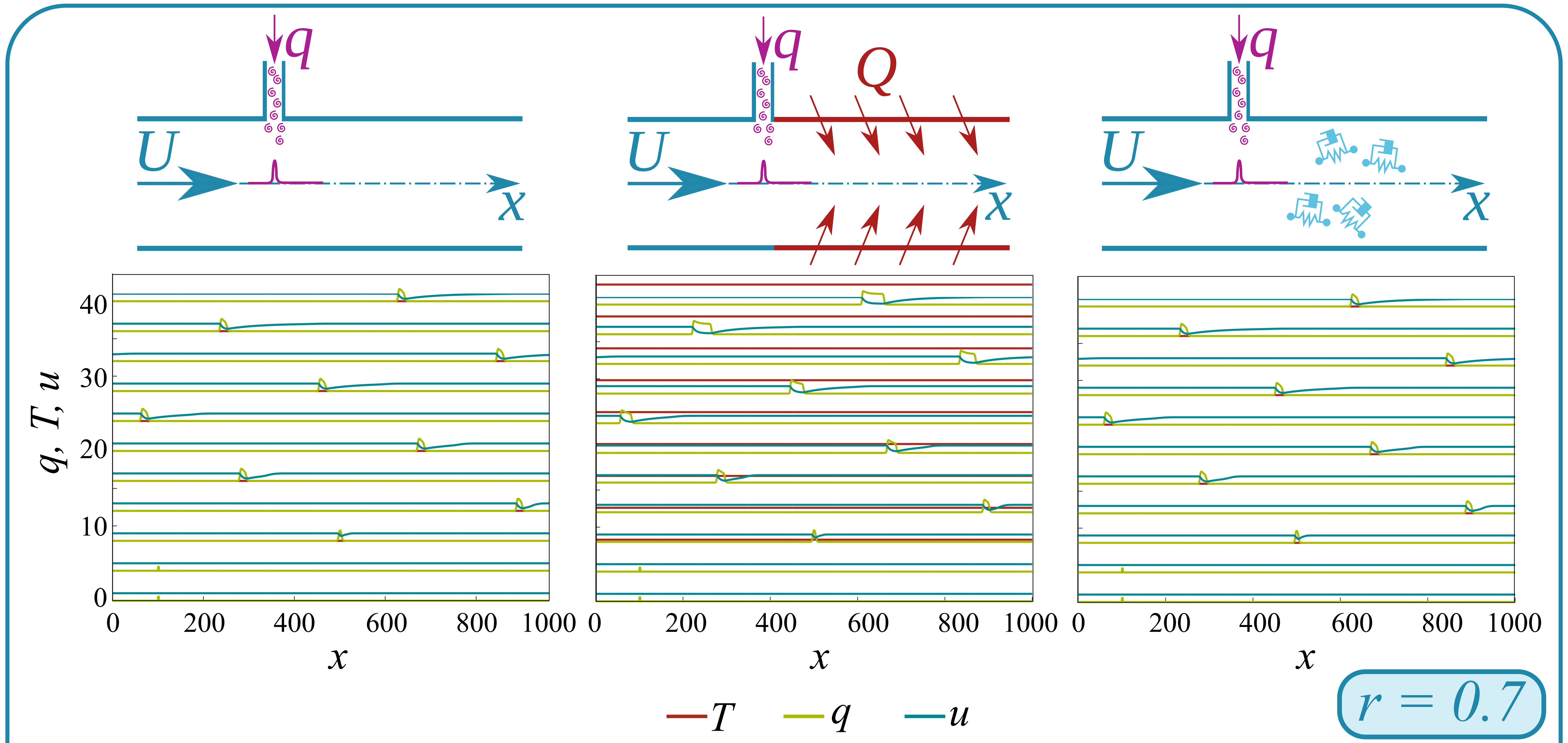

Building upon the model of Barkley, we generalize the reduced-order model by adding:

- the energy equation
- the thermal effect on the dynamic viscosity
- weakly non-Newtonian power-law effects (flow index $1>n>0.94$)

The transition to turbulence is among the most investigated topics in fluid mechanics as it relies on non-trivial phenomena that are not yet fully understood since the experiments of Osborne Reynolds in 1883. Several investigations focused on linear instabilities triggering the most dangerous perturbations that lead to transition in model flows such as the Kolmogorov flow or in paradigmatic setups such as the Taylor–Couette or the Rayleigh–Benard flows. On the other hand, when dealing with pipe flows, nonlinear interactions between finite-amplitude perturbations are essential for transition to turbulence as the Hagen–Poiseuille flow is linearly stable. Among the most interesting features of transition to turbulence in pipe flows there is the phenomenon of intermittent turbulence, where small turbulent regions (puffs) grow up to larger turbulent patches (slugs) and then they decay because of a restabilization of the mean velocity profile. This has been recently investigated by Barkley, *PRE* (2011), who proposed a reduced-order model that retains the essential non-linear effects of the momentum equation required to explain the intermittency, and the non-linear interaction between turbulent regions leading to transition.

Conclusions

- **Heating** up the pipe wall **strongly anticipate** the **turbulence**
- Weakly **non-Newtonian** effects play in **favor** of **turbulence**