Linear instability of pulsatile polymer channel flow

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Polymer flow attracts continual attention, partially because it is closely associated with engineering applications, e.g., drag reduction in pipe flows[1], the mechanism behind which is recently associated with flow instability[2]. The polymer channel flow of the Oldroyd-B fluid was found to be linearly unstable at smaller Reynolds numbers[3] than that of the classic channel flow of the Newtonian fluid[4]. These flows are driven by either a constant pressure gradient or in a constant flow rate, however, the flow rate and the pressure driving force often vary in time, such as in cardiovascular flows. The linear stability of the pulsatile channel flow of the Newtonian fluid has been investigated, and the effect of the pulsation on the critical Reynolds numbers is clearly identified[5]. In this study, we combine the effect of viscoelasticity and the pulsatile flow rate to examine the linear stability of the pulsatile polymer channel flow of the Oldroyd-B fluid. The competition of the characteristic timescale (pulsation period) of the base flow and the polymer relaxation time gives a complex mapping of the critical linear instability points in parameter space for this flow, as demonstrated by the energy amplification for an exampled group of flow control parameters, as shown in figure 1.

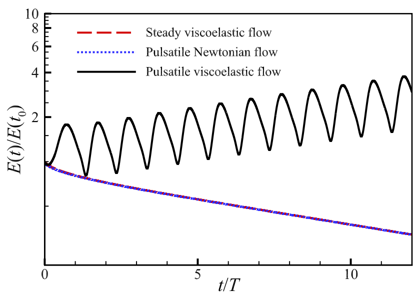

Figure 1: Time series of the energy amplification $E(t)/E(t_0)$ for the least stable or most unstable mode of the pulsatile Newtonian flow, pulsatile viscoelastic flow and steady viscoelastic flow, respectively. The former two share the same pulsation amplitude and frequency, while the latter two share the same elasticity and the same viscosity ratio. All three cases share the same Reynolds number.

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