Dynamics and Transport of a Solute in Taylor-Couette Flow Bounded by Permeable Walls*

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In this work, linear stability analysis and Direct numerical simulations (DNS) are used to investigate the coupling between hydrodynamic instabilities, membrane transfer and osmotic pressure in Taylor-Couette configuration. The emphasis is on characterizing the effect of the osmotic pressure related to the concentration boundary layer forming near the membrane on the structure and dynamics of Taylor vortices. We consider a Taylor-Couette cell with two semi-permeable membranes totally rejecting the solute transported by a newtonian fluid filling the gap. For fixed operating conditions, linear stability analysis shows that the osmotic pressure tends to alter centrifugal instabilities as a result of an original self-sustained mechanism coupling the advection of the concentration boundary layer by the vortices, molecular diffusion and osmotic pressure driving a transmembrane flow fostering the vortices. This mechanism can induce a substantial reduction of the critical rotation rate above which vortices are observed. Furthermore, stability analysis shows that critical conditions are also impacted by the radius ratio. These analytical results are compared to recent DNS.

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