Accepted Manuscript

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PII: S0997-7546(16)30471-X
DOI: https://doi.org/10.1016/j.euromechflu.2018.06.005
Reference: EJMFLU 3316

To appear in: *European Journal of Mechanics / B Fluids*

Received date : 11 October 2016
Revised date : 11 June 2018
Accepted date : 12 June 2018

Passive control of global instability in low-density jets

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Abstract

Many studies have shown that low-density jets exhibit self-excited varicose oscillations. We use direct numerical simulation of the low Mach number Navier–Stokes equations to perform a linear global stability analysis of a helium jet at the threshold of onset of these oscillations. We calculate the direct and adjoint global modes and overlap these to obtain the structural sensitivity. We find that the structural sensitivity has high magnitudes in the shear layer downstream of the entrance plane, where the flow is absolutely unstable. We use the direct and adjoint global modes to calculate the effect of a control force on the growth rate and frequency of the unstable mode. We produce maps of the regions of the flow that are most sensitive to localized open loop steady forcing in the form of a body force and a heat source. We find that the most sensitive location for open loop steady forcing is the area around the shear layer, around 2 jet diameters downstream of the exit plane, and that the influence of steady forcing and heat injection is advected by the flow outside the jet. We use these maps to calculate the influence of a ring placed in the flow. When the ring is at the same temperature as the flow, it influences the flow through its drag. The ring has most influence when placed in the inner edge of the shear layer. When the ring is heated, it also influences the flow through the density reduction caused by heat input. In this case, the ring has most influence when placed in the outer edge of the shear layer. It is also influential when placed outside the jet because the expanded gas is advected towards the jet. In both these cases, the influence

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