An insight into the non-local physical mechanism of impinging jet instability

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It is well known that high subsonic jets directed normal to a wall are able to produce, under particular conditions, intense discrete frequency sound waves called impingement tones. This phenomenon has been studied by a number of investigators in the past and is generally accepted that such tones are generated by a non local feedback loop among two kind of waves: a downstream-travelling wave, which is excited at the nozzle lip and propagates around the jet core position, and an upstream-travelling wave generated by the impingement of disturbances on the plate and propagates backward inside the jet core. The *non-local constructive* interaction of such waves gives rise to a self-sustained *global* in time instability, which in some circumstances, is able to radiate an intense acoustic field. In this work we analyse in details the characteristics of the global instability which drives the main characteristics of the flow field. In particular, a parametric global stability analysis will be performed by first calculating the unstable symmetric base flow and then by evaluating the leading eigenvalues and eigenvectors of the linearised compressible Navier-Stokes operator. The resulting spectra and the characteristics and nature of the associated leading unstable eigenmodes will be discussed. Further insight into the instability mechanism is gained by performing a weakly-nonparallel local stability analysis. The two component of the feedback mechanism, the forward convectively unstable *hydrodynamic* mode of Kelvin-Helmholtz type and the backward propagating waves of *acoustic* nature, will be precisely identified and the transmission and reflection coefficients of the waves will be locally extracted with the aid of an "adjoint projection" on the global eigenvector. The analysis will precisely unveil "the scattering region", i.e. the area where the excitation and the interaction of the local waves occur, providing important information on the resonant mechanism and the condition for sound radiation. The results will serve as a base for the possible identification of a quantitative "frequency selection criterion" and mode reconstruction procedure based on a local-type analysis.

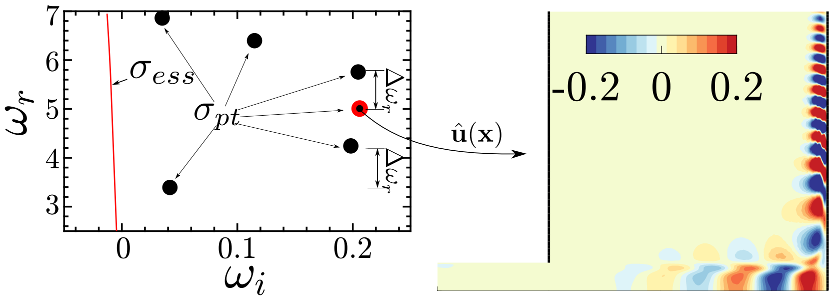

Figure 1: Example of spectrum at $Re = 1600$, $M_{max} \approx 1$ and leading eigenmode structure (axial velocity).

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