Two mechanisms of sound radiation by instability waves on a subsonic jet

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Despite a half century's efforts in aeroacoustics research, the accurate prediction of sound generated by turbulent jets remains an outstanding issue. A major obstacle is the lack of understand of physical mechanism in sound generation and radiation, in subsonic jet. Our initial motivation is to probe into the physical process of sound radiation in turbulent jets. So that we can develop a hierarchical hybrid approach to overcome the drawback of acoustic analogy.

The recent work of Zhang & Wu [2] has discussed the nonlinear interaction of the coherent structure and its emits low-frequency sound waves with the time and length scales comparable with those of the wave envelope, refer as "envelope radiation".

In present paper, the far field acoustic integration approach was built up base on asymptotic theory has been discussed in [2]. The nonlinear interactions of instability waves were calculated by nonlinear parabolized stability equations. A model problem in which the base flow corresponding to the experiment of the Mach 0.9, Re 3600 jet by Stromberg et al. (1980) was excited by two instability waves, at non-dimensional frequencies of 1.8 and 3.2. These waves interact nonlinearly to produce acoustic waves at the difference frequency of 1.4.

The results show that each instability wave contains supersonic components in their spectrum, some of them radiate to the far field and exhibits highly superdirectivity, just like "Mach-wave radiation". While, the difference frequency mode performs both, "Mach-wave radiation" and "envelope radiation". The former occurs at low polar angle, however, the latter happens to high angle. Comparison with linear modes [3] and experiments are discussed in detail.

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[1] Zhang and Wu, *J. Fluid Mech.* **924**, A39 (2022).

[2] Sandham and Salgado, *Phil. Trans. R. Soc. A.* **366**, 2745 (2008).

[3] Cavalieri, et al, *J. Fluid Mech.* **704**,388 (2012).

[4] Wu, *J. Fluid Mech.* **523**,121 (2005).

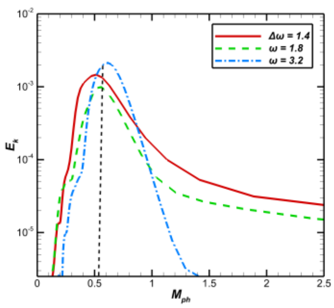

Figure 1. Energy of pressure against phase Mach number.

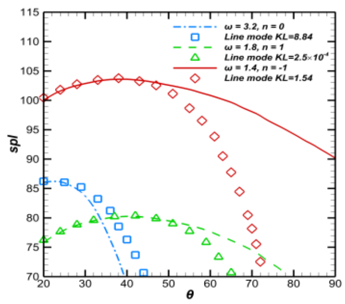

Figure 2. SPL curve at 30 diameters.