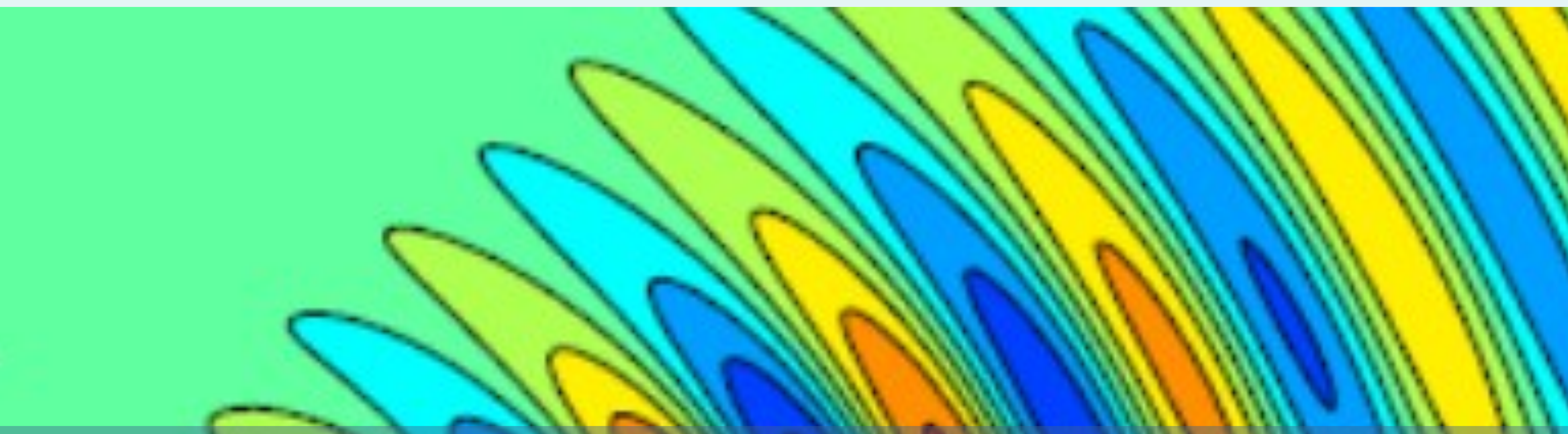

UNIVERSITY OF Southampton

Jet noise mechanisms

Aerodynamics and Flight Mechanics Research Group

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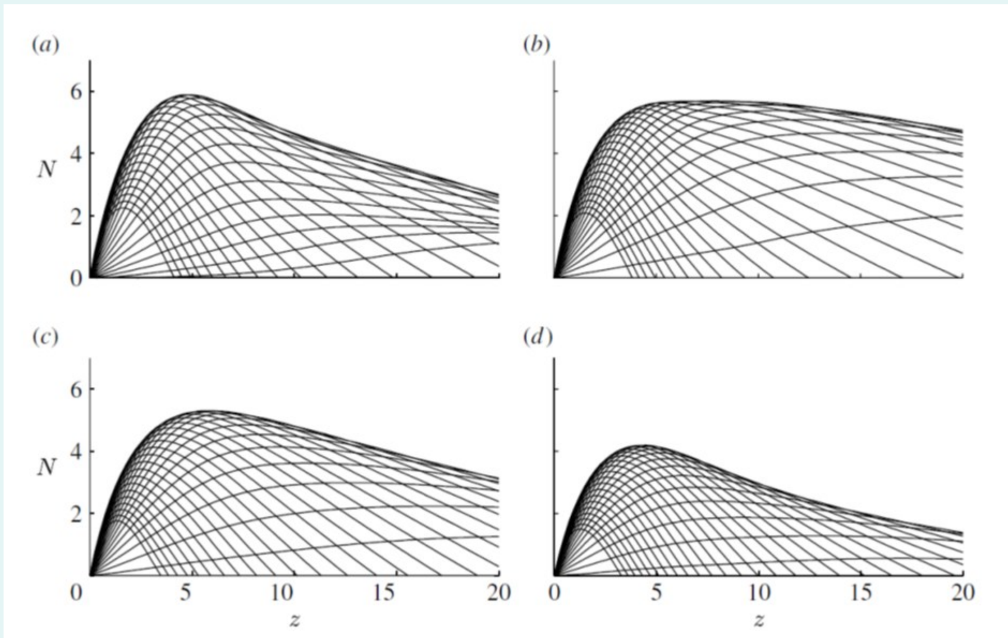
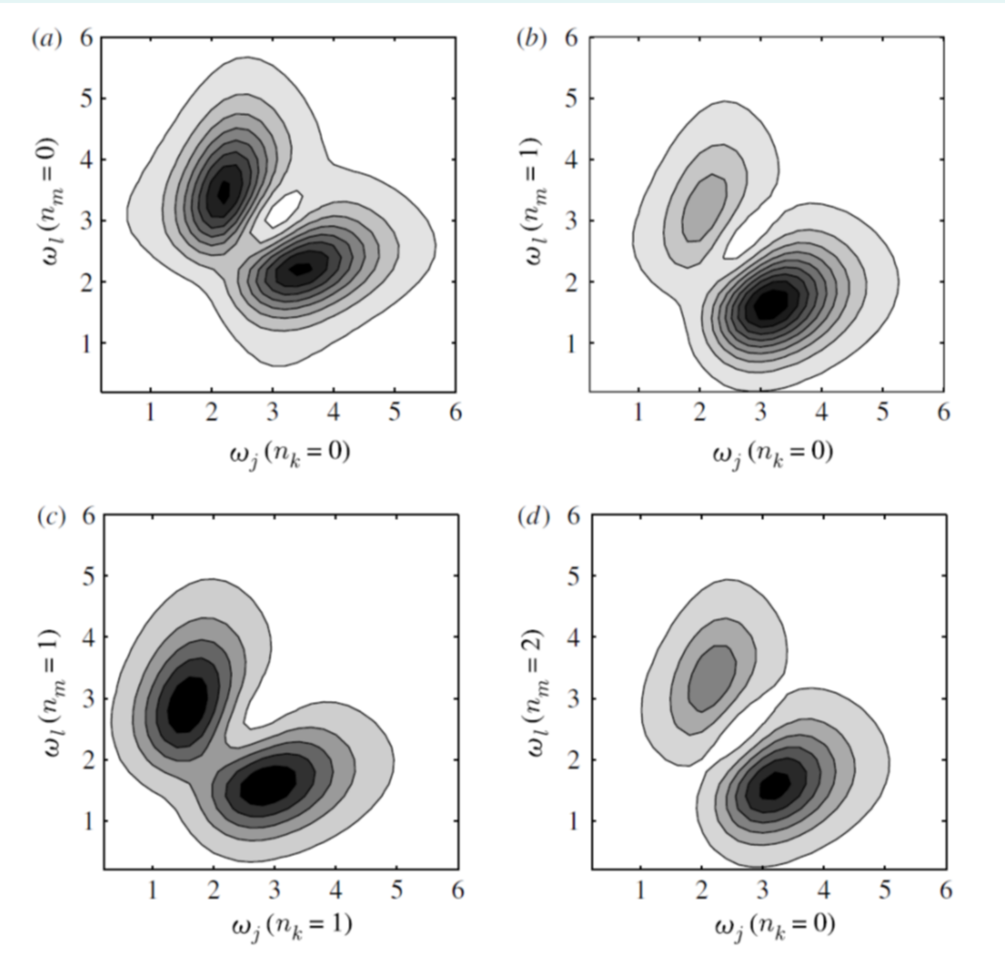
The sound radiation from subsonic jets is less well understood than that from supersonic jets where there is a direct connection between jet vortical structures and the Mach waves they produce. In subsonic jets the sound originates with wavepackets in the shear layers, but the question of what drives the wavepackets remains unclear.

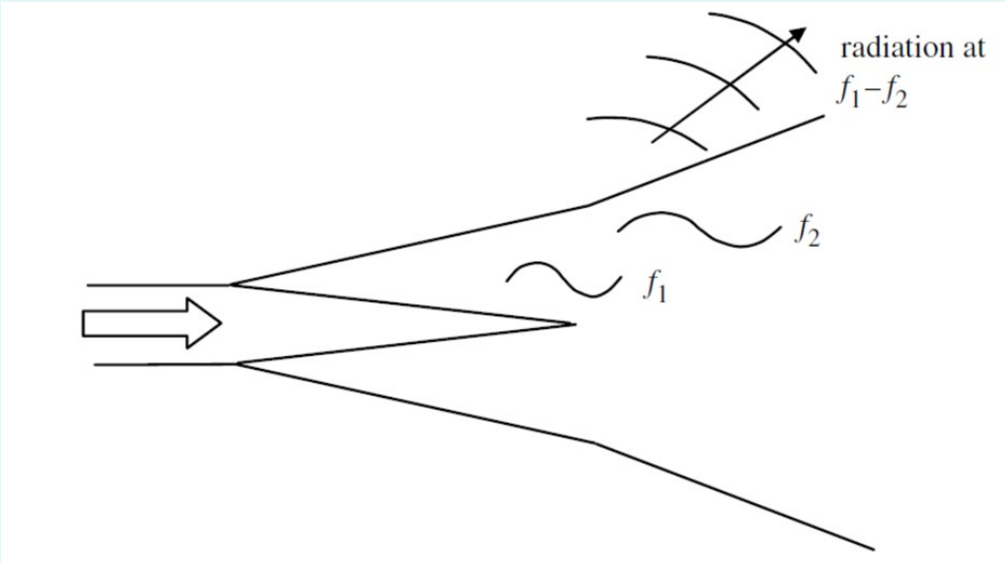
In this work we demonstrate that a wavepacket driven by a nonlinear interaction between two unstable modes in the jet provides a very efficient mechanism of sound radiation.



Wave amplitude envelopes for azimuthal modes: (a) n=0, (b) n=1, © n=2 and (d) n=3. The growth factor *N* for each case was computed with a linear PSE method. In each plot the curves corresponding to 30 different frequencies are plotted

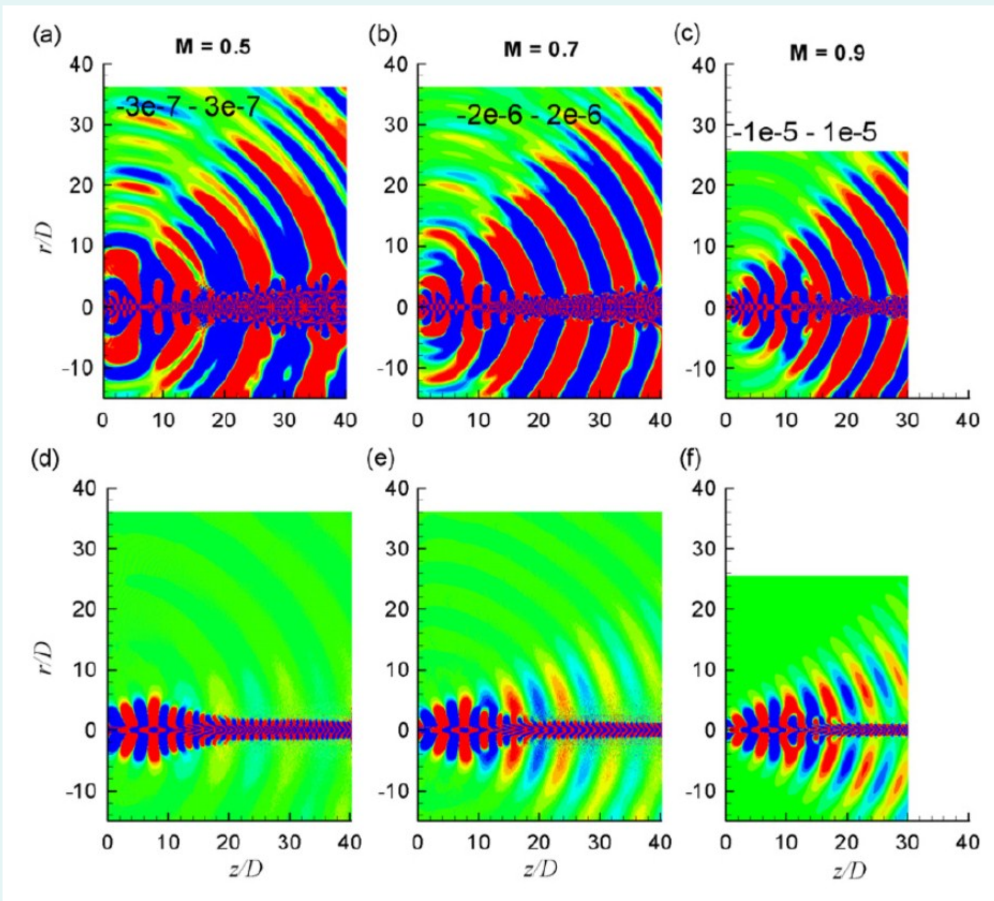


Difference mode amplitude plots, showing how different modes may combine to force the sound radiation

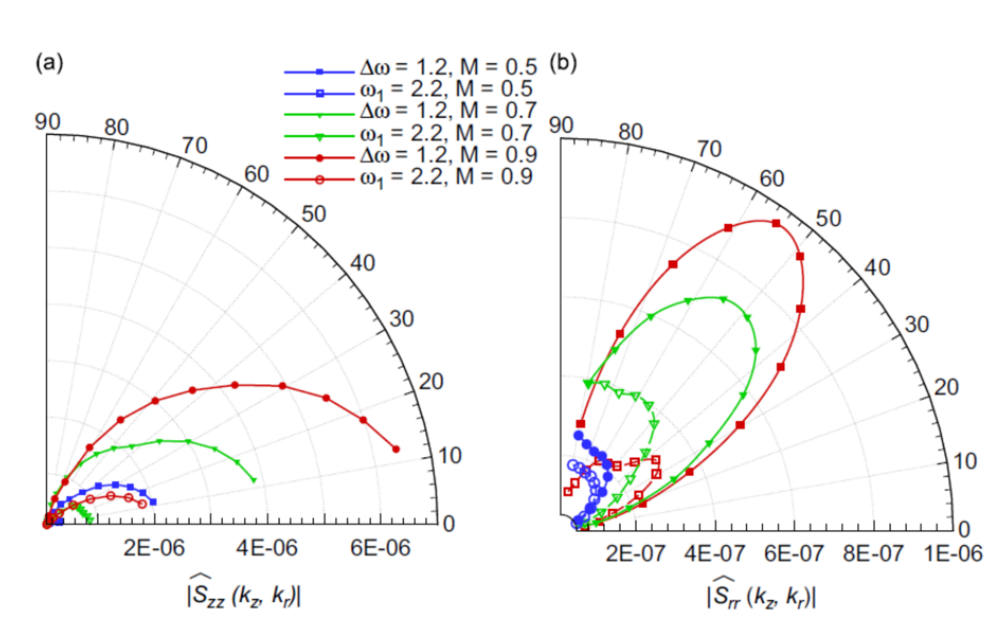


Schematic showing frequencies in the jet core and the corresponding difference mode in the acoustic field

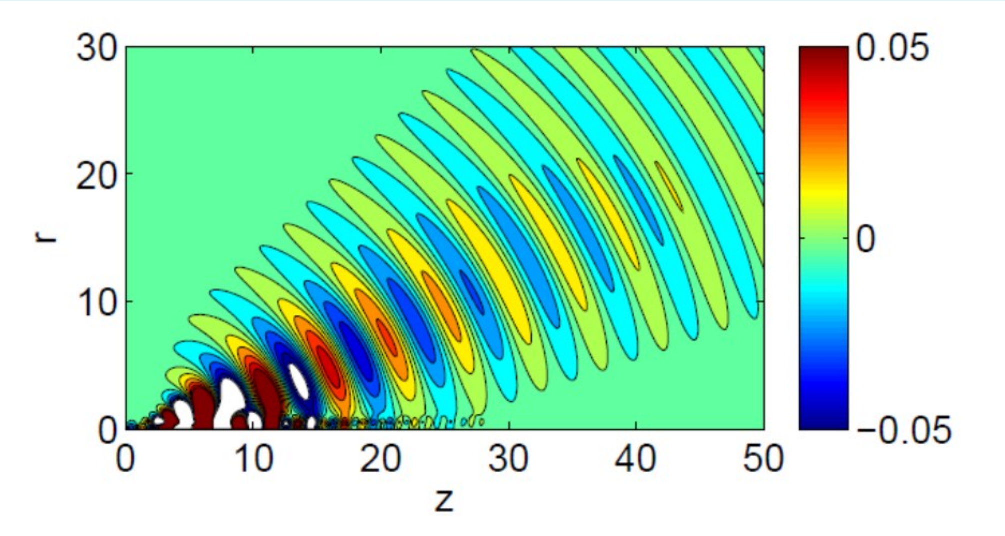
Theoretical predictions of the sound are made using the parabolised stability equations (PSE) and additional direct numerical simulations are used to solve the governing equations. The efficiency of the nonlinear mechanism is clear from the simulations and theory. The insight obtained enables the contributions of particular mode interactions to both the directivity and the spectrum of noise radiation to be assessed. Axisymmetric mode interactions are shown to be particularly important, which has implications for jet noise control.



Comparison of the effectiveness of the nonlinear mechanism (top three figures) with the linear mechanism (lower three), evaluated using direct numerical simulation of the governing equations for a single stream jet. From left to right, three different Mach numbers are considered: M=0.5, M=0.7 and M=0.9. The frequency of the sound is the same in each case.



Sound directivity comparing two sources: a longitudinal quadrupole (left) and a lateral quadrupole (right)



Pressure contours from a PSE calculation

References:

Sandham, N.D. and Salgado, A.M. Nonlinear interaction model of subsonic jet noise, *Philosophical Transactions of the Royal Society A*, 366(1876), pp2745-2760, 2008

Suponitsky, V., Sandham, N.D. and Morfey, C.L. Linear and nonlinear mechanisms of sound radiation by instability waves in subsonic jets, *Journal of Fluid Mechanics*, 658, pp.509-538, 2010

Suponitsky, V., Sandham, N. and Agarwal, A. On the Mach number and temperature dependence of jet noise: results from a simplified numerical model, *Journal of Sound and Vibration*, 330(17), pp4123-4138, 2011

Salgado, A.M. *Jet hydrodynamic and noise calculations using the parabolized stability equations*, PhD thesis, University of Southampton, 2012

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