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Implication of Taylor's hypothesis on amplitude modulation[1]

MICHAEL HOWLAND, XIANG YANG, Stanford University — Amplitude modulation is a physical phenomenon which describes the non-linear inter-scale interaction between large and small scales in a turbulent wall-bounded flow. The amplitude of the small scale fluctuations are modulated by the large scale flow structures. Due to the increase of amplitude modulation as a function of Reynolds number ($Re_\tau = \delta u_\tau / \nu$), this phenomenon is frequently studied using experimental temporal 1D signals, taken using hot-wire anemometry. Typically, Taylor's frozen turbulence hypothesis has been invoked where the convection by velocity fluctuations is neglected and the mean velocity is used as the convective velocity. At high Reynolds numbers, turbulent fluctuations are comparable to the mean velocity in the near wall region ($y^+ \sim O(10)$), and as a result, using a constant global convective velocity systematically locally compresses or stretches a velocity signal when converting from temporal to spatial domain given a positive or negative fluctuation respectively. Despite this, temporal hot-wire data from wind tunnel or field experiments of high Reynolds number boundary layer flows can still be used for measuring modulation provided that the local fluid velocity is used as the local convective velocity.

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