Anomalous sound attenuation behaviours in lined ducts

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It is well established that sound attenuation in a lined duct is mainly decided by the least attenuated mode. The least attenuated mode will have the maximum attenuation rate when lining impedance is close to the branch point or Exceptional point (EP) at which both the eigenvalues and their corresponding eigenfunctions of a pair of modes, the least attenuated mode and its neighbour, coalesce. Therefore, much effort has been devoted to increasing the attenuation rate of the least attenuated mode by tuning the liner close to EP. In this paper, we focus on the sound propagation in a 2D semi-infinite lined duct on the premise of no flow. The liner is assumed to be locally reacting and therefore is modelled as impedance. A source is located at $x = 0$ and will propagate to infinity. We show that the above conclusion is correct only when x is very large, or $x \to \infty$, i.e., the least attenuated mode only decides the asymptotic behaviour. When x is not very large, e.g., $kx < 20$, where </latex>$k= {\omega}/c_0$</latex>, called transient region, the total sound power could remain nearly no attenuation, even though the lining impedance is close to EP and the least attenuated mode has the maximum attenuation rate. We show that the sound pressure field resembles Gaussian beam and it circumvents the liner. This nearly non-attenuation sound field is achieved by a special source, we call it the worst source. We then concentrate on how to obtain this source and the relationship between the worst source and practical sources. The effects of other parameters on the transient behaviours, e.g., frequency, lining impedance, propagation distance, etc., are studied as well. This nearly non-attenuation sound field should be avoided in practically lined ducts.