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Destabilisation of shear flows by counter-propagating Alfven waves at localised magnetic fields

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The instability of shear flows in the presence of magnetic fields is fundamental to understanding a wide range of geophysical and astrophysical phenomena. We investigate the simplest paradigm problem of interest, which is the linear instability of a plane parallel shear flow with aligned field, to two-dimensional disturbances. We focus on cases where the shear flow has no inflexion points and is thus hydrodynamically stable, and show how such flows can be destabilised by the addition of two thin regions of magnetic field. An explicit analytical solution is presented for the case of a flow with uniform shear and where the magnetic fields are of infinitesimal width, showing that there is always instability for some range of along-stream wavenumbers. The strength of the instability is reduced for the more realistic case of magnetic fields of finite width, which can be investigated numerically, or analytically using matched-asymptotic expansions. The instability can be unambiguously attributed to the mutual amplification of a pair of counter-propagating Alfven waves, and should therefore be viewed as an extension to astrophysical fluid dynamics of various classical shear instabilities in geophysical fluid dynamics involving counter-propagating Rossby waves or gravity waves.