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Do smooth non-viscous atmospheric internal wave modes exist?

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Smooth normal modes are considered as the building blocks of linear non-viscous atmospheric and oceanic dynamics. The type of the corresponding boundary value problem that has to be solved to find such modes depends on frequency: for acoustic wave modes the type is elliptic, for internal wave modes the type is essentially hyperbolic, and for Rossby wave modes we obtain a boundary value problem of mixed type, hyperbolic for lower latitudes and elliptic for higher latitudes. It is known that hyperbolic and mixed type eigenvalue problems are mathematically ill-posed. Thus the existence of smooth internal wave modes is questionable.

We will solve simplified but also general internal wave boundary value problems of geophysical flows by standard finite difference methods. We will discuss typical features and shortcomings of such numerical solutions. It appears that the numerical solutions always possess discrete eigenvalue spectra even though discrete spectra do not exist for all hyperbolic or mixed type boundary value problems. Moreover, due to low resolution, the existence of singularities like internal boundary layers can easily be overlooked when numerical solutions are studied.