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Approximation schemes to dispersion and linear problems for 3D systems on shear current of arbitrary direction and depth dependence

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We compare different methods of approximating the dispersion relation for waves on top of currents whose direction and magnitude may vary arbitrarily with depth. Two fundamentally different approximation philosophies are in use: analytical approximation schemes, and what we term the N-layer procedure in which the velocity profile is approximated by a continuous, piecewise linear function of depth. The relative virtues of both schemes are reviewed.

The N-layer procedure yields the dispersion relation with arbitrary accuracy. We present the details and subtleties of implementing this procedure in practice. We find with a good choice of layer boundaries, 4-5 layers are sufficient for accuracy of about 1%. For inhomogeneous systems with a specified source, implementation is straightforward and most complications are eschewed.

Analytical approximation schemes are reviewed, and criteria of applicability are derived for the first time. In particular the much used approximation by Kirby & Chen (1989) (KCA) is compared with a new approximation which we propose. The two give similar predictions when the KCA is applicable, but our new scheme is more robust and can handle several special but realistic cases where the KCA fails.

Once the dispersion relation is calculated, 3D linear problems such as initial value problems, or problems with stationary or periodic time dependence can be readily solved.