

$$\frac{\partial h}{\partial t} + \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \epsilon_0 h = 0 \quad (7.26c) \quad ?$$

where  $F_0 = \tau_0 L / (c_0^2 \rho H)$  is the dimensionless amplitude of the zonal wind stress and  $\epsilon_0 = a_m L / c_0$  is the dimensionless linear damping coefficient. In a finite basin on the equatorial  $\beta$ -plane, the boundary conditions are

$$x = 0, 1 \quad : \quad u = 0 \quad (7.27a) \quad \text{XE [p. 11]}$$

$$y \rightarrow \pm\infty \quad : \quad u, v, h \rightarrow 0 \quad (7.27b)$$

With  $\mathbf{F} = (\tau^x, 0, 0)$  and  $\mathbf{u} = (u, v, h)$ , this system of equations can be written as

$$\mathcal{M} \frac{\partial \mathbf{u}}{\partial t} + \mathcal{L} \mathbf{u} = \mathbf{F} \quad (7.28a)$$

$$\mathcal{L} = \begin{pmatrix} \epsilon_0 & -y & \frac{\partial}{\partial x} \\ y & \zeta_0 \epsilon_0 & \frac{\partial}{\partial y} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \epsilon_0 \end{pmatrix} ; \quad \mathcal{M} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \zeta_0^2 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad (7.28b)$$

Applying Fourier transformation in  $x$ , according to

$$\hat{\mathbf{u}}(k, y, t) = \int_{-\infty}^{\infty} \mathbf{u}(x, y, t) e^{-ikx} dx \quad (7.29a)$$

$$\hat{\mathbf{F}}(k, y, t) = \int_{-\infty}^{\infty} \mathbf{F}(x, y, t) e^{-ikx} dx \quad (7.29b) \quad \text{XE [p. 11]}$$

then all  $x$ -derivatives in  $\mathcal{L}$  will transform to  $ik$  in  $\hat{\mathcal{L}}$  and  $\hat{\mathcal{M}} = \mathcal{M}$ . All free wave solutions of the previous section, say written as  $\hat{\mathbf{U}}$ , are solutions of the eigenvalue problem (for  $\epsilon_0 = 0$ )

$$\hat{\mathcal{L}} \hat{\mathbf{U}} = i\sigma \hat{\mathcal{M}} \hat{\mathbf{U}} \quad (7.30)$$

where  $\sigma$  is given through the dispersion relation (7.17).

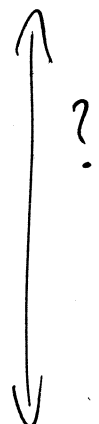
In the limit  $\zeta_0 \rightarrow 0$ , only the long (small  $k$ ), low frequency modes (small  $\sigma$ ) Rossby waves remain, having a dispersion relation and eigenfunctions for  $j = 1, 2, \dots$ ,

$$\sigma_j = \frac{-k}{2j+1} \quad (7.31a)$$

$$\hat{u}_j(y) = \frac{1}{2\sqrt{2}} \left( \frac{\psi_{j+1}(y)}{\sqrt{j+1}} - \frac{\psi_{j-1}(y)}{\sqrt{j}} \right) \quad (7.31b)$$

$$\hat{h}_j(y) = \frac{1}{2\sqrt{2}} \left( \frac{\psi_{j+1}(y)}{\sqrt{j+1}} + \frac{\psi_{j-1}(y)}{\sqrt{j}} \right) \quad (7.31c)$$

$$\hat{v}_j(y) = \psi_j(y) \quad (7.31d)$$



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