Symbolically we may write

$$\left(\frac{\partial}{\partial t}+\mathbf{v}\cdot\nabla\right)(\zeta+f)-f_0\frac{\partial\omega}{\partial p}=0 \qquad (1)$$

$$\left(\frac{\partial}{\partial t}+\mathbf{v}\cdot\nabla\right)\frac{\partial}{\partial p}\left(\frac{f_0}{\sigma}\theta\right)-\delta f_0\frac{\partial\omega}{\partial p}=0 \qquad (2)$$

Corresponding potential vorticity equation is given by $\delta\times$ (1) - (2). Then

$$q\equiv\delta(f+\zeta)-\frac{\partial}{\partial p}\left(\frac{f_0}{\sigma}\theta\right) \quad \text{and thus} \quad \overline{v'q'}=-\left[\delta\frac{\partial}{\partial y}\overline{u'v'}+\frac{\partial}{\partial p}\left(\frac{f_0}{\sigma}\overline{v'\theta'}\right)\right]$$

$$\frac{\partial\bar{u}}{\partial t}=f_0\hat{v}-\underbrace{\left[\delta\frac{\partial}{\partial y}\overline{u'v'}+\frac{\partial}{\partial p}\left(\frac{f_0}{\sigma}\overline{v'\theta'}\right)\right]}_{=\,\overline{v'q'}}-(1-\delta)\frac{\partial}{\partial y}\overline{u'v'}-g\frac{\partial}{\partial p}\bar{\tau}_x$$

$\overline{v'q'} \rightarrow 0$ for neutral waves without potential enstrophy cascade

Thus the noninteraction theorem does not hold with the Lorenz grid

where δ <1 (i.e., m is large),

such as immediately below a critical level and a region of large $\partial\bar{q}/\partial y$.

$$\left[\frac{\partial\bar{q}}{\partial y}=\beta-\frac{\partial^2\bar{u}}{\partial y^2}-f_0^2\frac{\partial}{\partial p}\left(\frac{1}{\sigma}\frac{\theta}{\alpha}\frac{\partial\bar{u}}{\partial p}\right)\right]$$