Letting $Q = q_x$, we start with

$$\partial_t \begin{pmatrix} \eta \\ Q \end{pmatrix} + \partial_x \begin{pmatrix} 0 & \Omega \\ 1 & 0 \end{pmatrix} \begin{pmatrix} \eta \\ Q \end{pmatrix} = 0, \ \hat{\Omega} = \frac{\tanh(\mu k)}{\mu k}$$