

$$\begin{aligned}
\widehat{[e^{D^t}g]}(k) &= \exp((\omega_q(k) - \omega_1(k_0) - [\nabla_k(\omega_q)](k_0)(k - k_0))t) \hat{g}(k) \\
&\approx e^{(k - k_0)[H\omega_1(k_0)](k - k_0)t} \hat{g}(k)
\end{aligned}$$