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Generic behavior of evolution equations: asymptotics and Sobolev norms

Consider the transport equation on the unit circle $\mathbb{T}$

$$u_t = ku_x - q(t,x)u, \quad u(0,x,k) = 1$$

The application of the Carleson theorem yields

Theorem. *If q is real-valued, $q(t,x) \in L^2([0,\infty),\mathbb{T})$, and*

$$\int_{\mathbb{T}} q(t,x)dx = 0$$

then there is $\nu(x,k)$ such that for a.e. k we have

$$\|u(t,x-kt,k) - \nu(x,k)\|_{H^{1/2}(\mathbb{T})} \to 0, \quad t \to \infty$$

We obtain analogous results for other evolution equations (e.g., the Schrodinger flow) that do not allow the exact formula for their solutions.