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Reducibility of the linear wave equation with unbounded perturbation

We prove the perpetual boundedness of the Sobolev norm of all the solutions of a quasi-periodically forced linear Klein-Gordon equation on the circle

$u_{tt} - u_{xx} + mu + Q(\omega t)u = 0,$

where Q is an unbounded pseudo-differential operator of order 2, parity preserving and reversible, provided that the forcing frequency belongs to a Borel set of asymptotically full measure.
This result is obtained by reducing the Klein-Gordon equation to constant coefficients, applying first a pseudo-differential normal form reduction and then a KAM diagonalization scheme.

A main point is that the equation is equivalent to a first order pseudo-differential system which, at the highest order, is the sum of two backward/forward trans- port equations, with non-constant coefficients, respectively on the subspaces of functions supported on positive/negative Fourier modes. A key idea is to straighten such operator through a novel quantitative Egorov analysis. This is a joint work with M. Berti, R. Feola and S. Terracina.