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Second harmonic generation of acoustic waves in a nonlinear elastic solid

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Nonlinear ultrasound higher harmonics have become increasingly useful as a nonintrusive probe of both microstructure as well as damage of solid materials [1]. The current theoretical underpinning of these e orts rely on a formula for the second harmonic that is proportional to the square of the linear wave and grows linearly with distance away from the source [2]. This formula holds only for small distances, since otherwise there would be a violation of the conservation of energy. This restriction is here lifted.
Consider the one-dimensional problem of wave propagation in a weakly nonlinear elastic solid with a time harmonic loading of frequency localized at the origin, for a displacement u(x; t) as a function of position x and time t on the whole real line. Using a successive approximation scheme starting with the linear case, and a multiple time analysis, an explicit formula is found for the second harmonic that is valid for all x [1]. The second harmonic so obtained is an amplitude-modulated wave. As indicated in the gure, for small distances from the source the usual formula found in the literature [2] is recovered.
Consequences of this result for non-destructive testing will be discussed.

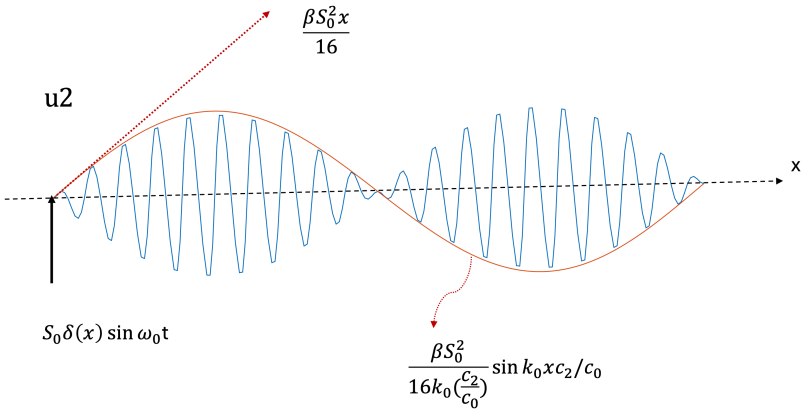

Figure 1:

References

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[2] C. M. Kube et al., A unifying model of weakly nonlinear elastic waves; large on large theory, J. Acoust. Soc. Am. 151 (2022) 1294-1310, http://dx.doi.org/10.1121/10.0009101.

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