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Nonlinear evolution of surface gravity waves and optical waves in dispersive materials

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We exploit the isomorphism between equation sets that govern the evolution of surface gravity waves and optical waves in dispersive nonlinear materials. This allows us to write down a generalised system of equations, where the model variables have different interpretation depending on whether the ocean or the optical material is being studied.

We use the method of multiple scales (MMS) to systematically eliminate artificially growing forced terms by imposing secularity conditions that, in turn, lead to the asymptotic far fields. These asymptotic fields correspond to the evolution of envelope wave packets over long times and distances, and satisfy the nonlinear Schrödinger equation in the strongly dispersive, weakly nonlinear limit.

The advantage of MMS with respect to other methods is that it derives the secularity conditions in a explicit manner requiring few assumptions. We clearly state all the approximations needed to derive the final isomorphism and we discuss its relevance in optical experiments with filaments and in the theoretical understanding of extreme events, such rogue waves in the ocean.