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Integrability, instabilities, and the onset of rogue waves

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Abstract. Recently, a direct construction of the eigenmodes of the linearization of 1+1, multicomponent, nonlinear, partial differential equations of integrable type has been introduced. This construction employs only the associated Lax pair, with no reference to spectral data and boundary conditions. In particular, this technique allows to study the instabilities of continuous wave solutions in the parameter space of their amplitudes and wave numbers, leading to the construction of the so-called stability spectra, which, for multi-component systems with more than two components, in general differs from the continuous spectra of the spatial Lax operator. In the context of modulation instability, it provides also a necessary condition in the parameters for the onset of rational solitons. The theory will be illustrated using the example of the plane wave solutions for a system of two coupled nonlinear Schroedinger equations in the defocusing, focusing and mixed regimes. The derivation of the stability spectra is completely algorithmic, and, in the case of plane waves, their study makes use of some basic ideas from algebraic-geometry. Indeed, it turns out that, for a Lax Pair that is polynomial in the spectral parameter, the problem of classifying the stability spectra is transformed into a problem of classification of certain complex curves. The method is general enough to be applicable to a large class of integrable systems and in principle to all typologies of their solutions: additionally to the system of two coupled nonlinear Schroedinger equations, it has already been successfully applied to the study of the plane wave stability for the system modelling the resonant interaction of three waves, and for a novel long wave-short wave system, which contains both the Yajima-Oikawa and Newell models as special cases. Moreover, when this method is applied to continuous wave solutions, the corresponding spectra can be used to predict the values of the spectral parameter leading to rational soliton (rogue wave) solutions and the instability regimes allowing for their formation.

This is a joint work with Marcos Caso-Huerta (Northumbria University), Antonio Degasperis (Roma ``La Sapienza''), Priscila Leal da Silva (Loughborough University) and Sara Lombardo (Loughborough University).

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