CURRICULUM VITAE

Francesco Coppini

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Personal Data

Name: Francesco Coppini

Education

November 2017- February 2021: PhD program in Physics.
Supervisor: Prof. P. M. Santini. Department of Physics, University of Rome "La Sapienza".

October 2017: Master's degree in Physics, 110/110.
Supervisor: Prof. O. Benhar. Department of Physics, University of Rome "La Sapienza".

January 2014: Bachelor's degree in Physics, 108/110.
Supervisor: Prof. F. Sciortino. Department of Physics, University of Rome "La Sapienza".

Academic Positions

March 2021-today: Research Fellow, department of mathematics, Northumbria University, Newcastle (UK).

Workshops organized

Integrable Systems In Newcastle (ISIN2022): patronized by London Mathematica Society and Northumbria University.

Research activity

My research activity is focused on the theory of anomalous waves (AWs) in nature, using the nonlinear Schrödinger (NLS) equation and its lattice and relativistic generalizations as basic models.
My research project consists in the following three main topics:

- Perturbation theory for the Fermi-Pasta-Ulam-Tsingou (FPUT) recurrence of NLS AWs. We have studied two important generalization of NLS: the Complex Ginzburg-Landau equation and the Lugiato-Lefever equation. They can be considered as NLS equations plus dissipative, diffusive and driving terms. We have treated this terms as perturbations of the NLS equation, and we have developed the right perturbation theory in order to obtain the quantitative variations induced on the FPUT recurrence of AWs. The variations in the dynamics of the AWs appearence has been interpreted as a variation induced on the gaps of the spectrum at each appearance. The effect of the perturbative terms has been calculated using finite gap spectral theory, in terms of elementary functions in the CGL case, and in terms of special functions in the LL case. Since we have shown how a very small dissipation induces O(1) effects on the dynamics of periodic AWs, evolving into slowly varying lower dimensional asymptotic states, and since dissipation can hardly be avoided in the physics involving AWs, we expect that the aforementioned asymptotic states will have to play a basic role in the theory of AWs in nature [1,2].

- AW dynamics on the lattice, using the Ablowitz-Ladik (AL) model. Using matched asymptotic expansion techniques (developed for the NLS model), we have constructed the dynamics of a finite periodic AL chain, generated by a generic perturbation of the unstable background solution, in the case of 1 and 2 unstable modes, and we have described them by an exact deterministic recurrence of AWs. As in the NLS case, the one and two soliton solutions of Akhmediev type play a basic role in the description of this dynamics. Unlike the NLS case, both focusing and defocusing regimes exhibit AWs behaviour, depending on the background amplitude. We subsequently have studied analytically the effect of a small linear loss or gain on the AL FPUT recurrence of AWs, developing the proper perturbation theory for discrete soliton equations. To do that, we have constructed the main spectrum of the AL lattice, corresponding to the initial perturbation of the background solution. We then have evaluate the effect of small linear loss or gain on the variation of the spectrum, in analogy with the continuous theory developed for CGL and LL equations[3].
- AWs dynamics in nonlinear relativistic field theories, using the Massive Thirring Model (MTM). We first constructed, using the classical Darboux transformations, a large variety of novel exact solutions of the MTM, over a trivial or non trivial background, including also AWs, and classified them as relativistic particle or tachyons. These solutions cannot be generated through the usual perturbation theory, since they correspond to singularities of coupling constant. We are presently studying, using the finite gap method, the AW Cauchy problem in the case of a finite number of unstable modes; we have already solved it, to leading order, in the case of one unstable mode, obtaining an exact Fermi-Pasta-Ulam recurrence of relativistic analogues of the Akhmediev breather[4].

Programming Languages

C, C++, Python, FORTRAN.

References

[1] F. Coppini, P. G. Grinevich and P. M. Santini, "Effect of a small loss or gain in the periodic nonlinear Schrödinger anomalous wave dynamics", Phys. Rev. E **101** (2020), 032204: DOI: 10.1103/PhysRevE.101.032204. (arXiv:1910.13176).

[2] F. Coppini and P. M. Santini, "The Fermi-Pasta-Ulam-Tsingou recurrence of periodic

anomalous waves in the complex Ginzburg-Landau and in the Lugiato-Lefever equations", Phys. Rev. E **102**, 062207. DOI:10.1103/PhysRevE.102.062207

[3] F. Coppini and P. M. Santini. "The Fermi-Pasta-Ulam-Tsingou recurrence of periodic anomalous waves on NLS type lattices: the Ablowitz-Ladik equations". Preprint 2022 (in preparation).

[4] F. Coppini and P. M. Santini. "The massive Thirring model: exact solutions and Fermi-Pasta-Ulam-Tsingou recurrence of periodic anomalous waves. I". Preprint 2022 (in preparation).