

The Hebrew University of Jerusalem , Nonlinear Physics Seminar

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"Particles hidden in soliton dynamics in more than one space dimension"

For decades, researchers that study soliton dynamics have toyed with the idea of viewing solitons as models for spatially extended particles, both within the framework of classical systems as well as in the context of Quantum Field Theory. In (1+1) dimensions, this idea is feasible; a soliton is localized along the x-axis at any time. However, in higher space dimensions, most known soliton solutions (also called line solitons) are not localized in space, hence cannot be exploited as models for spatially extended particles. This situation has led many researchers into the search for nonlinear evolution equations in more than one space dimension that have localized solutions.

In this talk, an alternative for the generation of localized structures, which emulate spatially extended particles, from line-soliton solutions of nonlinear evolution equations in more than one space dimension will be presented. Multi-soliton solutions will be mapped onto such structures by mappings that naturally emerge from the evolution equations. The idea will be demonstrated in the cases of two nonlinear equations: The Sine-Gordon equation in (1+2) and (1+3) dimensions and the Kadomtsev-Petviashvili II (KP II) equation, in (1+2) dimensions.

The study presents two important observations:

1) The definition of a "mass" is necessary for allowing for a particle interpretation of the localized structures. There is no guiding principle that tells one how to define the mass. The intuitively appealing and most obvious interpretation of the profile of a localized structure as a mass density, so that the mass is the integral of that profile over space, emerges as the preferred one. In the case of the KP II equation, it turns out to be the only definition that allows for a particle interpretation of the localized structures. With that definition, they emulate collisions of non-relativistic particles. In the case of the Sine-Gordon equation, this choice ensures that the structures emulate free, spatially extended massive relativistic particles.

2) The case of the Sine-Gordon equation offers a new mechanism for the generation of particle mass already at the classical level. The mass density obeys a wave equation that is driven by a source term, which is constructed from a multi-soliton solution of the Sine-Gordon equation.

