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Solitons of $F = 2$ Spinor Bose-Einstein Condensates

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Nonlinear dynamics of Bose–Einstein condensate (BEC) is a fascinating feature and a lot of studies have been focused on this subject. One novel property of BEC is an internal degree of freedom. Thanks to this freedom, we are guaranteed to have multi-component generalizations of nonlinear dynamics. In the one-dimensional uniform system, the dynamics of BEC is described by the Gross–Pitaevskii equation, well-known as a soliton equation. Many studies about soliton dynamics of BEC and its stability have appeared.

Recently, solitons of BEC with hyperfine spin $F = 1$ in the one-dimensional systemsboth with vanishing boundary conditions and nonvanishing boundary conditions were studied in detail. The method was the use of the integrability and explicit solutions of the matrix type of nonlinear Schrödinger equation. However, it seems that the application of the matrix nonlinear Schrödinger equation is only valid to the $F = 1$ BEC, and it has been a problem how to obtain solitons for higher spins.

We present several one-solitons for the $F = 2$ spinor BEC's with special choice of interaction. The alternative method is Hirota's bilinear transform. By generalizing the method for the multi-component equations, regardless of whether integrable or not the equations are, we can have one-soliton solutions. As a result, a novel shape of one-soliton has appeared.