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Twin laser cavity solitons: theory and applications

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For optical systems, spatiotemporal phenomena arise in the structure of the electromagnetic field in the plane orthogonal in the direction of propagation as a result of the nonlinear response of the materials to intense laser beams and the spatial coupling provided by diffraction. Dissipation and driving and/or feedback are the features that can bring about intriguing properties once introduced to the schemes. Among these, localized bright spots or "Cavity Solitons" (CSs) have received a great deal of attention because of their experimental feasibility in semiconductor microresonators and potential applications in information processing. This is because CSs are attractors, i.e. stable solutions towards which the system evolves spontaneously from a wide set of initial conditions. In systems with no external injection, e.g. in semiconductor lasers containing amplifier and absorber materials, the CSs behave as independent beams free to choose their frequency, phase and polarization, and for this reason they are called Laser Cavity Solitons (LCSs). LCSs can also form binary localized structures called twin laser cavity solitons which are created from a single spot when the injection pulse energy exceeds a threshold and are trapped by each other's attractive force exchanging energy so that the total intensity remains constant. Apart from their asymmetric intensity distribution, they show spontaneously rotating dynamics controllable via a bifurcation parameter representing the ratio of carrier lifetimes in the two materials. Moreover, circles of maximum phase values are found to form around the center of mass of the binary structure featuring rotation along with the twin LCSs. As these are continually shrinking toward the center of mass, they can sweep micro-particles to the center. Subsequently the dipole force provided by the asymmetric intensity distribution can make the particles rotate. This suggests the idea of a localized optical micro-motor potentially useful in manipulation of micro-particles and nano-fluids.

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