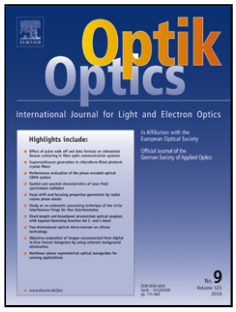

Title: Instability of multiple optical vortices in the media with quintic nonlinearity

Author: Xianjing Lai Xiao-Ou Cai Jie-Fang Zhang

PII: S0030-4026(17)30639-3
DOI: http://dx.doi.org/doi:10.1016/j.ijleo.2017.05.092
Reference: IJLEO 59241

To appear in:

Received date: 15-2-2017
Revised date: 28-5-2017
Accepted date: 29-5-2017

Please cite this article as: Xianjing Lai, Xiao-Ou Cai, Jie-Fang Zhang, Instability of multiple optical vortices in the media with quintic nonlinearity, *<![CDATA[Optik - International Journal for Light and Electron Optics]]>* (2017), http://dx.doi.org/10.1016/j.ijleo.2017.05.092

Instability of multiple optical vortices in the media with quintic nonlinearity

Xianjing Lai,[1] Xiao-Ou Cai,[1] and Jie-Fang Zhang[2,3]

[1]*Department of Basic Science, Zhejiang Shuren University, Hangzhou, Zhejiang 310015, P.R.China*
[2]*Zhejiang University of Media and Communications, Hangzhou 310018, Zhejiang, China*
[3]*School of Physics Science and Technology,*
Soochow University, Suzhou, Jiangsu 215006, P. R. China

In this short note, we perform theoretical analysis and numerical studies of the vortices in nonlinear optical media with spatially inhomogeneous quintic nonlinearity. We focus on the modulated profiles mainly composed of Whittaker and Jacobian elliptic functions, which both be constructed by means of similarity transformation. We give a further discussion, on the bases of linear static analysis and direct simulations. Studies have shown that the exact vortices are stable, while the numerically constructed ones are stable in some range of propagation constant. The unstable vortices are gradually decay into some splinters, the number of which relates to the perturbation index of the instability state with highest growth rate.

PACS numbers: 42.65.Tg, 42.81.Dp, 05.45.Yv

I. INTRODUCTION

Defocusing and focusing nonlinearities support dark and bright solitons respectively in homogeneous media. Nevertheless, transverse modulation of the refractive index may change this situation. For instance, photonic lattices, which is a periodic modulations, can influence the diffraction for the incident beams. In appropriate cases, bright solitons may appear even in the media with defocusing nonlinearity [1,2]. Besides linear modulation, the nonlinearity of media can be designed spatially non-uniform as well. The propagation of beams in the optical media with linear or nonlinear modulation has attracted a lot of attention [3]. Different from modulation with localized linear structures, there is no bright soliton under localized or periodic defocusing nonlinearities[4]. But, recent studies have shown that the stable bright solitons can be supported in media with inhomogeneous defocusing nonlinearity, whose strength grows sufficiently quickly toward the periphery of a material [5-8].

The nonlinear Schrödinger (NLS) equation can be widely applied in nonlinear optics. It can describe the propagation of spatial solitons in the optical nonlinear medium. Exact vortices can also be obtained in NLS equation by the self-similar transformations [9-22] when the nonlinearity modulated transversely.

Optical vortices are the electromagnetic wave that has a doughnut-like shape and possess a phase singularity that can be found in different types of nonlinear media. In this paper, we deals with the bright optical vortices in two-dimensional (2D) media with the spatially modulated quintic nonlinearity, including the 2D analytical vortices and numerically ones. We perform theoretical analysis and numerical studies to find the appropriate stabilizing conditions of multiple vortices and further seek out the characteristics of nonlinear optical excitation. So far to date, the quintic nonlinearity has been predicted theoretically in optics [23,24] and observed experimentally in fluids [25,26] and glasses [27-31]. In Bose-Einstein condensates, the quintic nonlinearity represents three-body interactions in a dense condensate, in case that collision induced losses may be neglected [32]. Ref. [33] studied the analytical vortex solitons in 2D NLS equation with spatially inhomogeneous cubic nonlinearity. Our purpose here is to test the similarity transformation for inhomogeneous nonlinearities, by using it to 2D quintic nonlinear media, which may be applied in optics. The stability of all the vortices is estimated through the computation of growth rates for the corresponding additional small perturbations and also confirmed by the split-step