Abstract

We want to find spatial solitons in optical fibres with a nonlinear optical Kerr effect. That's why we propose a new numerical approach using the Finite Element Method, very efficient for a natural treatment of inhomogeneous media in complex structures. A nonlinear scalar model of the electric field in the fibre is used to implement and to validate our method and to understand the physical meaning of the new solutions in a simple case. The field is supposed to be harmonic in time and along the direction of invariance of the fibre but inhomogeneous in the cross section. Several examples dealing with step-index fibres and solid core microstructured optical fibres (MOFs) with a finite size cross section are described. In each geometry, a complete study is achieved to obtain and to prove with numeric tests the existence of a single self-coherent nonlinear solution (spatial soliton) with the highest reachable energy avoiding the self-focusing instability. The spatial soliton depends on the finite transverse profile of the structure, corresponds to the Townes soliton in the nonlinear homogeneous medium but it is different in optical fibres. Our new approach of the numerical study of the optical Kerr effect in optical fibres permits us to generalize the Townes soliton. However, the refractive index profile induced by the optical Kerr effect shows that the weak guidance approximation is not respected and thus, the characteristics of the nonlinear solution are misvalued in the scalar model. Therefore, the implementation of the full-vector case without approximation is realized. The same study as for the scalar case is performed to take into account all electric field components. Finally, to extend the field of investigation of our numerical method, the nonlinear solutions in MOFs with a central hollow defect are studied. By analogy with Solid State Physics, donor/acceptor configurations are defined and nonlinear solutions are analyzed according to the size of the defect. The study of the focusing and defocusing case through these configurations allows us to discover new nonlinear behaviors in these fibres.