Half-Integer Topological Defects as Magnetic Monopoles in Polariton Condensates

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Abstraction is a common tool in physics, serving the better comprehension of complex phenomena. The most evident example is the atom, encompassing an intricate underlying structure of electrons and hadrons, the latter themselves composed of quarks and gluons. This internal structure can of course be completely neglected while discussing the properties of gases in statistical physics. Such multi-level abstraction is especially ordinary for solid-state physics, where excitons are formed from electrons and holes, themselves being complicated elementary excitations formed from several electronic levels of atoms constituting the solid. The excitons can be described as massive quantum particles, which can couple with photons and form new particles of an even higher level of abstraction - composite bosons called exciton-polaritons.

When a Bose-Einstein condensate [1] (BEC) is formed, one can consider its weak excitations as elementary particles (called bogolons), forgetting the nature of the underlying bosons. But the weak elementary excitations are not the only kind of interesting perturbation which can occur in a BEC. The topological defects [2] resulting from the non-linearity of the Gross-Pitaevskii equation and the irrotationality of the macroscopic condensate wavefunction are currently (and since quite a long time) in the focus of intense theoretical and experimental research, and will be the main topic of the present work. We shall see how their behavior can be described in terms of relativistic "material points" and "point charges" (an easy way) or in terms of underlying local spin dynamics (a harder way). The importance of such analogies as "magnetic charges" will thus become especially clear.

We will discuss the behavior of single half-solitons and half-vortices in spinor polariton condensates in the presence of an effective magnetic field (induced by the energy splitting between polarizations in wire and planar cavities). We will show that such topological defects behave as "magnetic charges", accelerating along the field [3]. Such a behavior is a special feature of half-integer topological defects, which also applies to the so-called oblique half-solitons [4]. We will see that their stability is maintained thanks to the spin anisotropy of polariton-polariton interactions [5]. Moreover, in the presence of an in-plane effective magnetic field integer topological defects may become unstable and split into half-integer ones, which will separate in real space due to the interaction with the field. We propose a practical way to create integer (or half-integer) topological defects in wire and planar cavities in a controlled way, in order to study their natural separation paving the way towards "magnetricity".

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