Local PT Symmetry Violates the No-Signaling Principle

The Hamiltonian is one of the most fundamental objects in quantum theory. It is used to describe the total energy of a physical system and governs the system's time evolution, and thus it is postulated to be Hermitian for having real energy and for conserving probability. A possible extension of this postulate, called Parity-Time (PT) symmetry, would require the Hamiltonian to have spatial- and time-reversal symmetry only, rather than the more restrictive Hermitian symmetry. This model was proposed in 1998 and stimulated much research to extend the fundamentals of quantum theory. Besides developing fundamental theory, PT symmetric theory also inspires a lot of research in classical optics. However, if such an extension is truly fundamental, some predictions of this theory would be extremely powerful, such as shortcuts in the evolution between two states or discrimination of two non-orthogonal states. Yi-Chan Lee from National Tsing-Hua University in Hsinchu City, Taiwan, and colleagues examine this new extension of quantum theory in the context of other physics principles, and show that the "local" form of PT symmetric theory would cause information transmission faster than light and thus is fundamentally flawed (or else special relativity is flawed, a highly unlikely proposition).

In their paper, they follow two implicit assumptions in PT symmetry theory, describing how it locally exists and how to consider the description of quantum states in this theory. They put these assumptions into a composite system which is considered often in quantum information science. In this composite system, Alice and Bob share a pair of maximally entangled spins. They find that Alice could send information to Bob with a speed faster than light by choosing adequate local operations and measurements. To avoid this issue, one has to insist the same symmetry in local operations and measurements. Nevertheless, according to other research the authors point out these restrictions would make PT symmetry theory only an effective version of quantum theory rather than a fundamentally new theory. Based on their result they believe that PT symmetry theory either reduces to another version of standard quantum theory or is likely false as a fundamental theory.

Yi-Chan Lee, *et al.*
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Efficient Sorting of Optical Vortices by Orbital-to-Spin Angular Momentum Coupling Effect

The spin and orbital angular momentum (OAM) are two independent degrees of freedom of the single photons, and each can be exploited for encoding information in both the classical and quantum regimes. Beyond the 2-dimensional thinking with photon spin, the significance of photon OAM lies in its potential in realizing a high-dimensional Hilbert space, as the OAM number carried by twisted photons, ℓ, can theoretically take any integers.

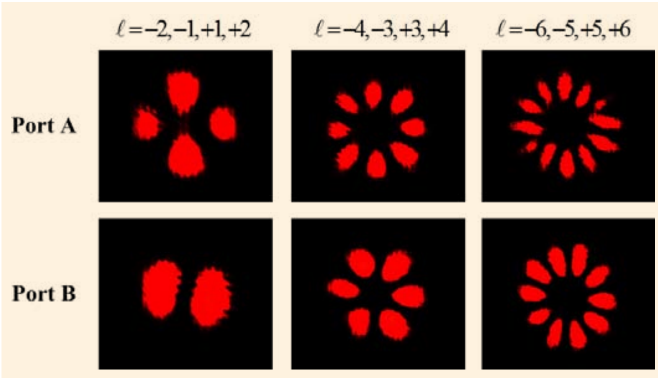

Fig. 1. Experimental results of sorting a mixture of multiple OAM. The top and bottom panels are the petal-like flower patterns recorded at different output ports of the interferometer.

The efficient sorting of OAM plays a fundamental role in a variety of applications with twisted photons. Recently, a research group led by Prof. Lixiang Chen from Xiamen University in China devised and demonstrated a new experiment of mimicking Faraday rotation to sort the photon OAM efficiently. Their scheme was based on the orbital-to-spin angular momentum coupling effect induced by a modified Mach-Zehnder interferometer. Discovered by Michael Faraday in 1845, the well-known Faraday effect describes a rotation of polarization caused by the interaction of light with a magnetic field in a chiral material. In contrast, Lixiang Chen and coworkers were able to rotate the polarization of the incoming photons according to individual OAM. The rotation angle was simply proportional to the input OAM number ℓ, namely, $\theta = \ell$, where α described the relative orientation of a pair of Dove prisms embedded in their interferometer. Based on this ingeniously designed sorter, they have demonstrated the separation of both a single OAM and a mixture of multiple OAM, and the characteristic single bright rings and petal-like flowers have been observed, respectively. Furthermore, they have succeeded in sorting