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Moyal phase-space analysis of nonlinear optical Kerr media

The Moyal equation of a quantum observable corresponds to a phase space representation of its Heisenberg equation of motion. Because the latter has a close relation to the corresponding classical dynamics, the Moyal method is ideally suited to study the transition from classical to quantum behaviour in a system. The Moyal representation is related to the Wigner function like the Heisenberg picture is related to the Schroedinger picture. Unfortunately the Moyal equation is difficult to solve so that only few exact solutions are known.

We have studied nonlinear optical self-phase modulation of Kerr type using the Moyal equation for a single optical field mode. An exact solution for the annihilation operator is found. The phase space representation of this operator is related to the classical field amplitude by a complex factor that shows characteristic singularities in time. We show that these singularities disappear in the classical limit and demonstrate how the uncertainty relation prevents that observable quantities are affected by it.