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Operator-based method for finding exact solutions of the propagator equation in the presence of a magnetic field

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Elementary particle processes in the extreme astrophysical conditions, such as strong magnetic fields, require knowledge of the exact propagators. There are known expressions for the propagators of scalar, Dirac and massive vector fields in the presence of the constant magnetic field both in the coordinate and in the momentum spaces. In general they require either following the tedious Fock-Schwinger procedure or first obtaining the exact solutions of the wave equation of interest followed by summation over the allowed quantum numbers. In this work we present a general method of obtaining the exact analytical solutions of the propagator equation based on the decomposition of the delta function into the sum of the Hamiltonian-like operator eigenfunctions with the subsequent integration of the corresponding operator exponent in the proper time domain. Providing that parts of the operator exponent commute, it becomes possible to decouple them from each other and apply each part separately to the delta function decomposition series. This method not just allows to straightforwardly obtain the expression for the propagator in the momentum space as a sum over the Landau levels, but also helps to gain insights into the propagator's anatomy, revealing the origins of its constituent parts.

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