

New Wine in an Old Bottle? Surprise with Angular Momentum

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We analyzed mathematical conditions that are used in obtaining the eigenvalue spectrum of the orbital angular momentum operator in non-relativistic quantum mechanics. As it turns out, if one retains only those conditions that are the mathematical realization of physical requirements, the eigenvalue spectrum is discrete, admitting integer, as well as non-integer eigenvalues. Relation for the eigenvalues reads $|m| = L - k$, where L is the eigenvalue of the square of the angular momentum operator, m is the eigenvalue of the third component of the angular momentum operator and k are the integers that do not contradict the non-negativity of $|m|$. The eigenfunctions corresponding to this spectrum, form an orthonormalized basis and the Hilbert space of physical states can be constructed through them. As an auxiliary task, the uniqueness of the exponential function of the complex variable and its invariance with regard of axes rotations at 2π was considered. It is shown that the well-known Euler-De Moivre prescription used to define the power function of the complex variable as a single-valued function is just one of the special cases for unambiguously determining power function with the non-integer exponent, spontaneously breaking invariance of the initial expression with regard rotations at 2π for non-integer exponents. We present another prescription for uniquely defining power function of the complex variable in the framework of which the rotational invariance is preserved for integer as well as non-integer exponents.

Main point is that from quantum mechanics it does not follow that the eigenvalues of the angular momentum operator are necessarily integer.

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