UNVEILING THE QUANTUM TOROIDAL DIPOLE OF A NANOSYSTEM, ITS QUANTIZATION, INTERACTION ENERGY, AND MEASUREMENT POSSIBILITIES

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We analyze a quantum particle in a quasi-2D system of cylindrical symmetry, which, in concrete cases is a torus with the coordinates (θ, ϕ, ξ), as shown in Fig. 1. We focus on the toroidal dipole of the particle [1] and show that the operator associated to it is self-adjoint, so it may correspond to an observable. We numerically solve the eigenvalue and eigenvectors problem (EEP) for the free Hamiltonian and try to apply the same procedure to the operator of the toroidal dipole projection on the z axis $\hat{T}_3$, but the convergence is not good. In [2] we analytically solve the (EEP) for $\hat{T}_3$ and find that the eigenvalues are discrete and equidistant, whereas the eigenvectors are of infinite norms, i.e., they are eigenfunctionals, not eigenfunctions. This implies that they *cannot be numerically calculated using any orthonormal basis functions*. Furthermore, this raises fundamental problems related to the measurement principle, since the wavefunction of the system cannot collapse on a function of infinite norm as the result of a measurement.

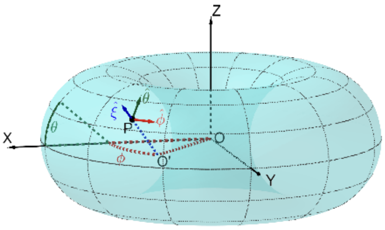

Fig. 1: A quantum particle in a quasi-2D system of cylindrical symmetry [in most cases, a torus, with the toroidal coordinates (θ, ϕ, ξ)].

We also show how we can indirectly measure T_3 by its interaction energy, by passing a current along the z axis (Fig. 1).

References

[1] M. Dolineanu, A.T. Preda, and D.V. Anghel, *The toroidal dipole operator in nanostructures*, Physica A **598**, 127377 (2022).
[2] D. V. Anghel and M. Dolineanu, *The eigenvalues and eigenfunctions of the toroidal dipole operator*, Phys. Scr. **98**, 015223 (2023).
[3] A.L. Nastasia, M. Dolineanu, and D.V. Anghel, *Unveiling the Quantum Toroidal Dipole of a Nanosystem*, to be submitted.