# Proximity influence of adjacent fields on extended states: Schrödinger nonlocality as a probe for quantization of macroscopic quantities and application to novel magnetoelectronic devices

**Konstantinos Moulopoulos**

University of Cyprus, Department of Physics, Nicosia, Cyprus
cos@ucy.ac.cy

**Abstract:** A novel effect in Planar Physics is reported, that shows that, under certain conditions, interesting physics may occur ***outside*** magnetic or (time-dependent) electric field regions: A *proximity influence* of a static magnetic field *on adjacent regions* in *flat* 2D space is shown to be a natural consequence of the Aharonov-Bohm effect combined with the nonexistence of magnetic monopoles. This influence is confirmed through a recent theory[1,2] that goes beyond the standard Dirac phase factor (and that incorporates wavefunction-phase-nonlocalities) and affects numerous results in the literature on extended (and open) arrangements with *inhomogeneous* magnetic fields**:** under certain conditions, there seems to be a gauge-ambiguity remaining, that has been overlooked in all previous works. The deep origin of this annoying feature is explained and it is shown that it can be removed when outside (remote) fluxes are properly quantized. This theory therefore suggests natural ways to eliminate the artificial effect *for confined systems* (closed manifolds), and it has a direct generalization even to cases with effective magnetic monopoles present, leading to quantization of macroscopic quantities (response functions) in a wide range of systems of current interest. Examples include application of such phase-nonlocality (*i*) to a spherical geometry, that leads to the standard Dirac quantization of magnetic monopoles without further topological or gauge considerations, (*ii*) to a cylindrical configuration, by additionally invoking Axion Electrodynamics, that naturally leads to fractional quantization of dyons (the Witten effect), as well as quantization of "Witten current", leading in turn to the quantization of Hall conductance, either (*a*) in whole, or (*b*) in half integral units of $e^2/h$ (corresponding (*a*) to conventional Quantum Hall Effect systems, and (*b*) to the recently predicted exotic magnetoelectric phenomena in time-reversal-symmetric topological insulators, respectively). A similar consideration with adjacent electric fields (that vary with time) leads to the possibility of manufacturing of interesting quantum devices (that properly utilize the proximity influence to induce Integral Quantum Hall Effect and other topological phenomena in novel time-dependent ways from *outside* the system). For *t*-dependent fields, the time-derivative of the above phase-nonlocalities is shown to be directly related to very recent considerations of Berry and Shukla[3] on "curl forces" that are spatially confined in classical systems, giving simultaneously their quantum generalization (or quantization). Finally, a combination of proximity influence with proper Lorentz boosts can also induce Aharonov-Casher edge states, thereby inducing spin-physics such as Quantum Spin Hall Effect, starting from purely orbital considerations.

## References

[1] K. Moulopoulos, Journal of Modern Physics, **2** (2011) 1250-1271.
[2] K. Moulopoulos, Journal of Physics A, **43** (2010) Art. No.354019.
[3] M.V. Berry and P. Shukla, Journal of Physics A, **45** Art. No.305201.