# Dressing of Quantum Atmospheres by Pseudoscalar $\boldsymbol{E} \cdot \boldsymbol{B}$ Fields

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**Abstract**— According to the Heisenberg's uncertainty principle, vacuum is alive with spontaneous fluctuations in the electromagnetic field configurations on the Planck constant action scale. Photonic materials with the electric $\epsilon$ and magnetic $\mu$ parameters dress the densities of vacuum states defining the Purcell factors of their quantum atmospheres [1]. Quantum atmospheres can be further augmented by application of external fields to enhance amplitude dependent local symmetry breaking and potentially generating transient hidden phases of matter. This is relevant for creation of environments where the parity $\mathcal{P}$ and time $\mathcal{T}$ symmetries are broken, but the joint $\mathcal{PT}$ symmetry remains preserved. Such atmospheres support the $E \cdot B \neq 0$ pseudoscalar fields where the polarizability $\theta$ couples to axion electrodynamics. We perform ultrafast nonlinear photoemission electron microscopy imaging of surface plasmon polariton fields at a silver-vacuum interface [2] recording their vectorial field and spin properties with 50 attosecond precision as they propagate and their textures evolve on 15 nm spatial scale. By geometry of the surface plasmon polariton generating structures, we harness the spin-orbit interaction of light to tailor structured topological plasmonic vortex fields. From vectorial analysis we conclude that the fields possess skyrmion and meron spin textures as periodic arrays [3–5]. We find that the phase singularities of vortex cores host $E \cdot B \neq 0$ pseudoscalar fields that persist on time scale of the generating optical fields, where the associated magnetoelectric density is focused on a deep subdiffraction limited scale [6], and the plasmon spin textures take form of magnetic monopoles [3]. We conclude that the plasmonic vortices host quantum atmospheres that promote coupling to axion electrodynamics of topological, magnetoelectric, and cosmological nature [7].

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