Quantum Vacuum Radiation and Time-Reversal Symmetry
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Vacuum consists of a bath of balanced and symmetric positive- and negative-frequency fluctuations. Photonic media in relative motion or accelerated observers can break this symmetry and preferentially amplify negative-frequency modes as in quantum Cherenkov radiation and Unruh radiation. Here, we show the existence of a universal negative-frequency-momentum mirror symmetry in the relativistic Lorentz transformation for electromagnetic waves. We show the connection of our discovered symmetry to parity and time-reversal symmetry in moving media and the resulting spectral singularity in vacuum fluctuation related effects [1,2].

We will also discuss topological symmetries of the electromagnetic vacuum and connection to bosonic topological insulators for light. We exploit the correspondence between Dirac’s equation and Maxwell’s equation to predict the existence of a spin-1 bosonic topological insulator. We will discuss a photonic Dirac monopole present in vacuum and map its conserved topological quantum numbers to a continuous photonic medium. Our Dirac-Maxwell theory to understand topological properties of photons, integer spin bosons, marks a shift in approach from existing Schrodinger-Maxwell analogies. We show the time-reversal symmetry protected edge states of a bosonic topological insulator which have open boundary conditions, unlike any known surface electromagnetic state. Our work shows that a degenerate optical chiral medium, if found in nature, would be the best candidate for a spin-1 bosonic topological insulator [3,4].

[1] Singular evanescent wave resonances in moving media, Y Guo, Z Jacob, Optics express 22 (21), 26193-26202 (2014)