Sixteenth Marcel Grossmann Meeting

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Orientability of space from electromagnetic quantum fluctuations

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Orientability is an important topological property of spacetime manifolds. It is generally assumed that a test for spatial orientability requires a journey across the whole 3-space to check for orientation-reversing paths. Since such a global expedition is not feasible, theoretical arguments that combine universality of physical experiments with local arrow of time, CP violation and CPT invariance are offered to support the choosing of time- and space-orientable spacetime manifolds. We show that it is possible to access spatial orientability of Minkowski spacetime through local physical effects involving quantum electromagnetic fluctuations. To this end, we study the motions of a charged particle and an electric dipole under these fluctuations in Minkowski spacetime with orientable and non-orientable spatial topologies. We derive expressions for an orientability indicator for both point-like particles in two spatially flat topologies. For the particle, we show that it is possible to distinguish the orientable from the non-orientable topology by contrasting the evolution of the indicators. This result shows that it is possible to access orientability through electromagnetic quantum fluctuations. The answer to the question on how to locally probe the orientability of Minkowski 3-space intrinsically arises in the study of the dipole's motions. We find that a characteristic inversion pattern exhibited by the dipole indicator curves is a signature of non-orientability. This result makes it clear that it is possible to locally unveil spatial non-orientability by the inversion pattern of orientability indicator curves of an electric dipole under quantum electromagnetic fluctuations. Our findings open the way to a conceivable experiment involving quantum electromagnetic fluctuations to locally probe the spatial orientability on the microscopic scale of Minkowski spacetime.

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