DESY
Particle and Astroparticle Physics Colloquium

Physics of θ-Vacuum and Inevitability of Axions in Standard Model and Gravity.

Tuesday, 11 March, 2025
Auditorium & Webcast 16:00 h

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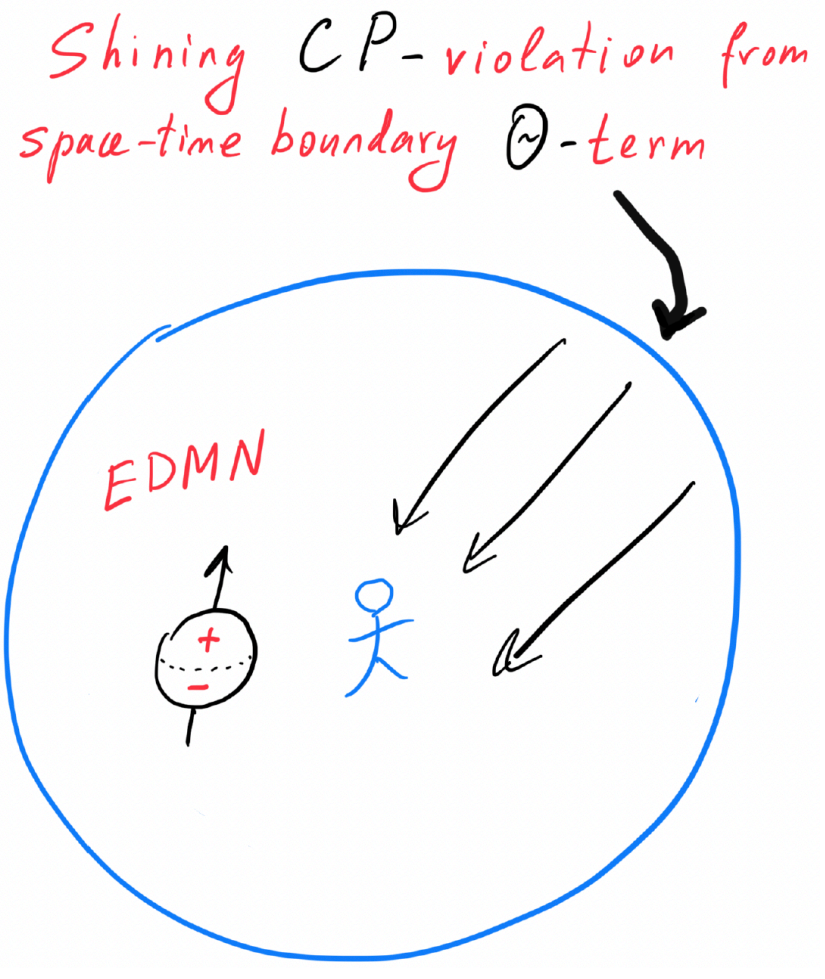
In this talk we explain from the basic properties of QFT why the CP-violating θ-vacuum is a built-in feature of the Standard Model and how the mass of the η′-meson provides a direct experimental evidence for it. We then explain how the axion protects CP dynamically and define the axion-quality measure. This discussion, in particular, will make it transparent that the η′-meson is nothing but a poor-quality axion. Next, we introduce the so-called gauge formulation of axion in which the axion emerges as intrinsic part of QCD gauge redundancy without the need of any anomalous global symmetry. Unlike the original Peccei-Quinn formulation, by the power of gauge symmetry, the gauge axion has the exact quality, as it is protected agains arbitrary continuous deformations of the theory. We then discuss how gravity opens up a whole new perspective on the axion, promoting it into a consistency issue. Namely, once coupled to gravity, every topologically non-trivial gauge sector must be accompanied by the axion of exact quality. This requirement must be fulfilled by gravity itself which, due to Eguchi-Hanson instantons, possesses the CP-violating θ-vacuum. Strikingly, this implies the existence of a "gravi-axion", a pseudo-Goldstone coupled via the gravitational chiral anomaly of spin-3/2 fermions. Thus, the gravitational θ-vacuum demands the existence of local supersymmetry. Finally, the weak sector of the Standard Model must be accompanied by a designated "weak axion" that neutralizes the electroweak instantons. We discuss various phenomenological and cosmological implications of the presented topics.



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