Physics Team: CPT Invariance

Svende Braun, Johann Brehmer, Patrick Mangat

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Summary

The CPT theorem states that any quantum field theory that is local, unitary, and invariant under Lorentz transformations has to be invariant under the combined charge conjugation (C), parity transformation (P) and time reversal (T). The three requirements are fundamental building blocks of our current understanding of physics, which makes it very hard to construct a theory that breaks CPT invariance. But theorists always find a way, and CPT invariance can be broken in highly curved spacetimes (which may lead to apparent unitarity violation) or after the spontaneous breaking of Lorentz symmetry in certain frameworks of quantum gravity.

While a violation of CPT symmetry may seem unlikely, the implications would be huge, so there is a lot of experimental activity to test its predictions. One can show that CPT invariance predicts that particles and their antiparticles have equal mass, equal lifetimes, same electric opposite charges and equal anomalous magnetic moments. Interestingly these statements can be tested with a variety of experimental techniques, ranging from high-energy physics experiments measuring Kaon decays and Meson oscillations to low energy precision experiments based on atomic physics using Positronium spectroscopy and Penning traps. We focused on the so-called 'Antimatter-experiments' at CERN: Athena, Alpha, Atrap and Aegis, which aim to measure the 1S-2S transition frequency and the effect of gravitation on anti-hydrogen. So far from all different experimental searches, no sign of CPT violation has been discovered.

Physics team review

Our approach to this project was a coordinated literature review: after distributing topics and choosing the literature together, we worked through the material independently, with occasional discussion sessions. Overall, we are happy with the project. We got to know an interesting aspect of quantum field theory that is not usually covered in lectures, and had fruitful discussions. However, we had some trouble to get started: due to a lack of good (and easy-to-find) review articles, especially on the experimental side, it took us very long to get an overview of this wide topic.

References

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