One Question to Rule the Future of Physics

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Essay

The path of physics over the next century depends on the answer to a simple question:

Is it possible to store and retrieve data in an energy-free vacuum?

- If you say yes, the path mathematical physics has followed for the past century is in excellent shape and can move forward with no significant changes.

- If you say no, the deepest math foundations of modern theoretical physics, including quantum field theory and general relativity, must be rewritten from the ground up.

The beauty of this question is how profoundly dumb it sounds. Everyone knows data storage is never free. How can such an absurd question be relevant to theoretical physics?

Consider a microscopic location in an empty region of intergalactic space. Quantum field theory requires this location to support, simultaneously and with extraordinary fidelity, the amplitudes of all photons and neutrinos in the universe whose wave functions intersect with it. If it cannot, it loses its ability to maintain unitarity in all of those wave functions, and the conservation laws of physics are lost. Conversely, if it can represent all of those amplitudes with sufficient resolution to ensure the integrity and unitarity of their overall wave functions, the number of data storage bits required becomes truly "astronomical."

But this is nonsense! The wave function is the mathematical perfection guiding reality, not reality itself. The Born rule protects the implied bits of the wave function precision and thus are not directly available to anyone querying such locations classically.

Unfortunately, that's not entirely true, and Einstein's lenses again provide an example. Such a lens queries amplitude chains from vast sections of the entire universe, yet can transform them back into mundane, well-located photons or neutrinos. For this to happen, the amplitudes throughout that volume must be valid and maintain sufficient precision to reconstruct the original photon. All lenses do this, albeit usually at much smaller scales, so even an ordinary lens implies that the bit-precision storage capacity of every point of the vacuum along the way is genuinely immense and at least indirectly accessible. This vast data storage capacity of space is the deeper reason why all quantum field theories have problems with infinities. They are intrinsic to Faraday's original concept of a vector field.

What alternatives exist? One hint is the smoothness and redundancy of vast quantum fields, which suggest that a less repetitive representation of reality is required. Another is special relativity, whose deeper lesson is that writing "xyzt" already presumes too much.

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