広島大学

第 571 回物性セミナー

Dissecting the Foundations of Physics: Approaching Apparently Inaccessible Domains

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日　時　2025 年 11 月 18 日(火) 14:00 ~ 15:30

場　所　先端科学総合研究棟 405N

Is physics ultimately described by real numbers or some other structure? Laboratory measurements cannot address this question, but constraints arising from mathematical logic can, by supposing the parameters of physics are real numbers and exploring the consequences. First, I show that the notion of generic reals (introduced by Cohen to address issues in set theory) arises naturally in physics, using arguments rooted in Jaynes's maximum entropy principle. In turn, this allows one to demonstrate that theoretical and experimental physics rely on real numbers in distinct and conflicting ways, indicating that basing physics on the real numbers is problematic. In addition, I identify a second constraint on the use of real numbers, a phenomenon I dub algorithmic symmetry breaking, in which computability theory and Chaitin complexity imply an incompatibility between the foundational symmetries of physics and the notion of physics as algorithmic. This all points to physics being founded on a mathematical structure other than real numbers; I discuss the outline of a possible resolution, and the parallels between this and the shift from classical to quantum framework for physics.

※共同セミナー「理工学融合共同演習」認定科目です

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