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Quantum field theory, quantum reference frames and the type of local algebras

Wednesday 2 April 2025 09:00 (45 minutes)

Algebraic quantum field theory (AQFT) assigns a von Neumann algebra to each bounded spacetime region, generated by the associated observables. Under reasonable assumptions, these algebras are all isomorphic to a specific von Neumann algebra of type III1 [1], leading to significant physical differences between quantum field theory and quantum mechanics. Recently, Chandrasekaran, Longo, Penington and Witten (CLPW) [2] have argued that the inclusion of gravity can require the introduction of an "observer", and that the physical observables constitute an algebra of type II. This talk will explain these developments and their significance, without assuming familiarity with von Neumann algebras or AQFT. I will focus on the CLPW model and an operationally motivated generalisation [3], which reinterprets the observer as a quantum reference frame (QRF), and sheds light on the roles of gravity and the QRF/observer.

[1] D. Buchholz, C. D'Antoni, and K. Fredenhagen, The Universal Structure of Local Algebras, Comm. Math. Phys. 111 (1987) 123-135.

[2] V. Chandrasekaran, R. Longo, G. Penington, and E. Witten, An algebra of observables for de Sitter space. JHEP 2023(2) 1-56.

[3] C.J. Fewster, D.W. Janssen, L.D. Loveridge, K. Rejzner and J. Waldron, Quantum Reference Frames, Measurement Schemes and the Type of Local Algebras in Quantum Field Theory, Comm. Math. Phys. 406 (2025) 19:1-87.

Presenter: FEWSTER, Christopher (University of York, UK)

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