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For the past 15 years or so, the model theory of operator algebras has been a very active and exciting branch of applied model theory [1]. Initially introduced in the mid-20th century to put quantum mechanics on a firm mathematical footing, operator algebras has since become a flourishing area of mathematics, interacting with a variety of other fields, including group theory, ergodic theory, probability theory, and noncommutative geometry. In this talk, we given an introduction to the model theory of a particularly important operator algebra known as the **hyperfinite $\mathbf{II}_1$ factor**, denoted $\mathcal{R}$. While quite easy to define, the model theoretic behavior of $\mathcal{R}$ is strikingly complicated and is tied to a number of important operator-algebraic issues.

The first lecture of the tutorial will introduce $\mathcal{R}$ and tracial von Neumann algebras more broadly. It will also discuss the model-theoretic framework for studying such objects. The second lecture will study basic model-theoretic questions about $\mathcal{R}$, such as: does it have quantifier-elimination? Is it stable? Is it pseudofinite? The third lecture will discuss the fascinating connection between the question of the decidability of the universal theory of $\mathcal{R}$, a famous open problem in operator algebras known as the **Connes embedding problem**, and quantum complexity theory. The final lecture will discuss two applications of the model theory of $\mathcal{R}$ as it pertains to problems around ultrapowers of tracial von Neumann algebras.

No prior knowledge of operator algebras will be assumed in these lectures.

[1] Isaac Goldbring (ed.), ***Model theory of operator algebras***, Studies in logic and its applications, DeGruyter, 2023.