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The Eerie Oneness of Mathematics and Physics

Mathematics is freakishly good at describing the universe. For instance, it is possible to derive the fundamental laws of quantum mechanics from mathematical first principles, without even knowing what a hydrogen atom is. This talk will investigate this eerie oneness of mathematics and physics via the *Heisenberg group*, an easily-defined structure with far-reaching and deep applications. I will begin by deriving the Heisenberg group from elementary matrices, then explain how a simple matrix group can give us insights into Fourier analysis and quantum mechanics. In particular, I will demonstrate the relationship between the Heisenberg group and the celebrated but widely misunderstood Uncertainty Principle. Finally, I'll discuss some novel attempts to prove variations of the Uncertainty Principle. These topics were investigated by myself, Kirk Hendricks (University of Arizona), and Recep Çelibi (Lafayette College) as part of the Fields Undergraduate Summer Research Program 2015, under the supervision of Dr. Hadi Salmasian (University of Ottawa).