An introduction to Szemeredi's Theorem and Green-Tao's Theorem

Tatchai Titichetrakun
University of British Columbia (Ph.D. Graduated)

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Abstract: One of the most important theorems in additive combinatorics is Szemeredi's Theorem which states that a dense subset of integers must contain some additive structures, in particular, arithmetic progressions. Not only that the statement of the theorem is beautiful but also the methods that are interesting and connected many areas of mathematics such as Fourier analysis, ergodic theory, hypergraph theory. We will explore some basic ideas behind the proof such as the concept of structure and pseudorandomness, uniformity norms and inverse theorem, density increment method, energy increment method and regularity lemma.

In the second part, we will discuss transference principle which enables us to transfer the result on dense subsets of integers to some "pseudorandom" sparse subset of integers, for example, to the set of primes. This is first due to Green using Fourier analysis (for arithmetic progressions of length 3), Green-Tao using energy increment method and Gowers using Hahn-Banach Theorem.