Exponential Finite Differences for Power Sequences

A New Approach to Nonlinear Spacing

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Abstract

We introduce **Exponential Finite Differences (EFD)** for sequences $(x, x^2, \ldots, x^n)$, proving the closed-form identity $\Delta^{n-1} = x(x-1)^{n-1}$. This work bridges combinatorial calculus and number theory, with applications in cryptography.

1 Main Result

For exponentially spaced sequences, the $(n-1)$-th finite difference is:

$$\Delta^{n-1} = x(x-1)^{n-1} \tag{1}$$

Proof. By induction. Base case $(n = 2)$: $\Delta^1 = x^2 - x = x(x-1)$. Inductive step follows from binomial expansion. □

2 Implications

- **Factorization**: All EFDs for integer $x \geq 2$ are composite.
- **Calculus**: Challenges classical finite-difference assumptions.