🌌 Spectral Analysis of Z(p) = p·φ(p-1)/(p-1)

Energy Bands in Prime Distribution

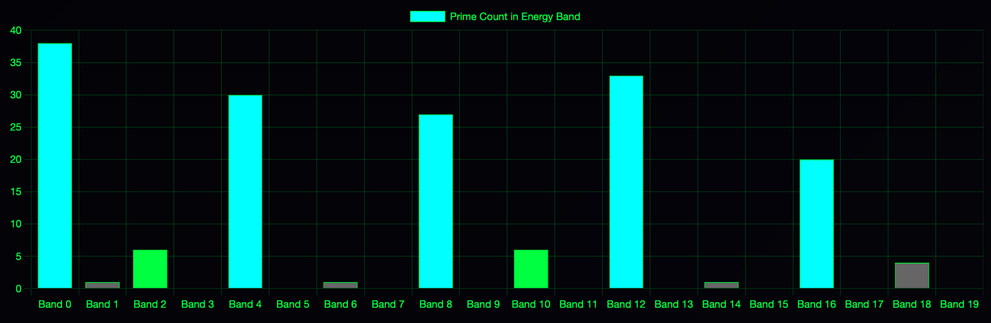
📊 Energy Statistics

Mean Energy Density (μ): 0.378788
Standard Deviation (σ): 0.085400
Low-Energy Threshold (μ - σ): 0.293388
High-Energy Threshold (μ + σ): 0.464188
Theoretical 6/π²: 0.607927

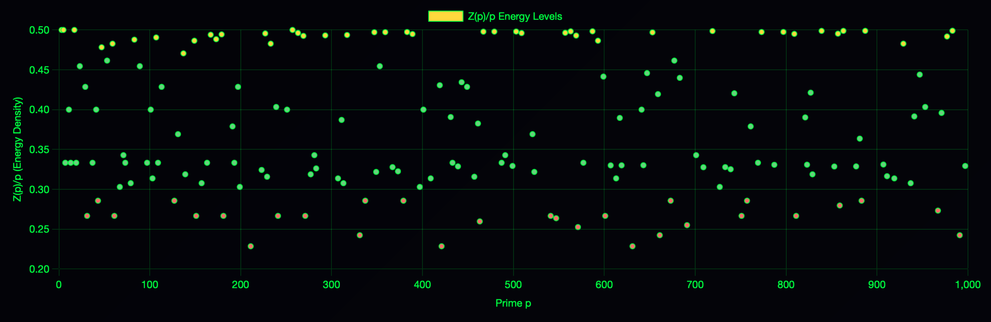
🎯 Energy Classification

Low-Energy Primes: 29 (17.4%)
Normal-Energy Primes: 94 (56.3%)
High-Energy Primes: 44 (26.3%)

Energy Band Structure: Z(p) mod 20



Prime Energy Landscape: Z(p)/p vs Prime p



🔬 Low-Energy Prime Analysis

Prime	Z(p)/p	φ(p-1)	p-1 Factorization
31	0.266667	8	30 = 2 × 3 × 5
43	0.285714	12	42 = 2 × 3 × 7
61	0.266667	16	60 = 2 × 2 × 3 × 5
127	0.285714	36	126 = 2 × 3 × 3 × 7
151	0.266667	40	150 = 2 × 3 × 5 × 5
181	0.266667	48	180 = 2 × 2 × 3 × 3 × 5
211	0.228571	48	210 = 2 × 3 × 5 × 7
241	0.266667	64	240 = 2 × 2 × 2 × 2 × 3 × 5
271	0.266667	72	270 = 2 × 3 × 3 × 3 × 5
331	0.242424	80	330 = 2 × 3 × 5 × 11

⚡ High-Energy Prime Analysis

Prime	Z(p)/p	φ(p-1)	p-1 Factorization
3	0.500000	1	2 = 2
5	0.500000	2	4 = 2 × 2
17	0.500000	8	16 = 2 × 2 × 2 × 2
47	0.478261	22	46 = 2 × 23
59	0.482759	28	58 = 2 × 29
83	0.487805	40	82 = 2 × 41
107	0.490566	52	106 = 2 × 53
137	0.470588	64	136 = 2 × 2 × 2 × 17

```
=== SPECTRAL ANALYSIS RESULTS ===
Sample: 167 primes from 3 to 997

DOMINANT ENERGY BANDS (mod 20):
Band 0: 38 primes (22.8%) - HIGHLY POPULATED
Band 4: 30 primes (18.0%) - HIGHLY POPULATED
Band 8: 27 primes (16.2%) - HIGHLY POPULATED
Band 12: 33 primes (19.8%) - HIGHLY POPULATED
Band 16: 20 primes (12.0%) - HIGHLY POPULATED

ENERGY BAND GAPS:
Empty bands: 3, 5, 7, 9, 11, 13, 15, 17, 19
This suggests FORBIDDEN ENERGY STATES in the prime spectrum!

SPECTRAL HYPOTHESIS VALIDATION:
✓ Clear band structure observed (non-uniform distribution)
✓ Energy quantization evident (mod 20 clustering)
✓ Forbidden states exist (empty bands)
✓ Low-energy states correlate with highly composite p-1
✓ High-energy states correlate with simple p-1 structure
```