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## 7. Max Planck – Birth of Quantum Theory

### 1) Brief Biography & Context

Max Planck (1858–1947), a German physicist, is widely regarded as the father of quantum theory. In 1900, he introduced the idea that energy is emitted and absorbed in discrete packets (quanta), solving the blackbody radiation problem and laying the foundation for modern quantum mechanics.

### 2) Core Theory (Blackbody Radiation & Energy Quantization)

Planck proposed that the energy of cavity oscillators is quantized:

$$\text{Equation: } E = n h \nu$$

Where:

$n$  = integer (0, 1, 2, ...)

$h$  = Planck's constant ( $\approx 6.626 \times 10^{-34}$  J·s)

$\nu$  = frequency of oscillation

From this postulate he derived the Planck radiation law:

$$\text{Equation: } I(\nu, T) = (2 h \nu^3 / c^2) \cdot 1 / (\exp(h \nu / k T) - 1)$$

Symbol Key:

$I(\nu, T)$  = spectral radiance (per unit frequency) of a blackbody at temperature  $T$

$c$  = speed of light in vacuum

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$k$  = Boltzmann constant

$$\exp(x) = e^x$$

This formula accurately explains blackbody radiation across all wavelengths, resolving the classical “ultraviolet catastrophe.”

### 3) What the Theory Explains Clearly

Discrete energy exchange (quanta) rather than continuous emission.

Accurate prediction of the blackbody spectrum at all temperatures.

The necessity of a fundamental quantum scale set by  $h$ .

A basis for Einstein’s photon hypothesis and the development of quantum mechanics.

### 4) Unresolved Issues / Limitations

Initially treated quantization as a mathematical device, not a physical mechanism.

Did not explain why energy should be quantized — only that it fits observations.

Classical–quantum divide persisted until the full quantum formalism emerged.

The deeper meaning of  $h$  remained open in Planck’s original approach.

### 5) Planck’s Perspective

Planck was conservative and hesitant to abandon classical physics. He introduced energy quanta as a ‘desperate remedy’ to fit experimental data. Over time, he acknowledged that this move marked the beginning of a fundamentally new physics.

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## 6) CUWF Interpretation (Closing the Gap) — Extended

### 6.1 Planck's Constant as a Fundamental Wave Unit

Within CUWF,  $h$  is the minimum action phase step the Still Wave lattice can sustain — the smallest 'note' of the universal waveform. Energy quanta reflect the indivisible phase increments of the lattice.

### 6.2 Why Energy is Quantized (Lattice Allowance)

The Still Wave lattice only supports standing-wave solutions that satisfy global phase closure and energy minimization. Therefore, only discrete resonance modes are permitted, which appear as quantized energies in matter and radiation.

### 6.3 Planck Law as Resonance Distribution

The Planck spectrum reflects the statistical population of lattice-allowed resonances across entropy gradients ( $\mathcal{E}$ ). Higher-frequency modes entail greater entropic cost, yielding the characteristic exponential suppression.

### 6.4 Why Classical Physics Fails

Classical theory assumes continuous oscillators and thus overcounts high-frequency modes. CUWF restricts the spectrum to discrete harmonics embedded in the lattice, preventing divergence at high  $\mathbf{V}$ .

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## 6.5 Connection to the CUWF Main Function

Energy quantization emerges when phase contributions in the universal wave function demand integer resonance, collapsing into discrete levels. Planck's constant is the macroscopic fingerprint of this discretization.

## 7) Summary & Transition

Planck's quantization solved the blackbody problem and initiated quantum theory.

CUWF explains why quantization exists: the Still Wave lattice admits only phase-coherent resonances, with  $h$  as the fundamental action step. This naturally leads into Bohr's atomic quantization and, subsequently, Schrödinger's wave mechanics.