# Welcome to Quantum Mechanics

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  Albert Einstein

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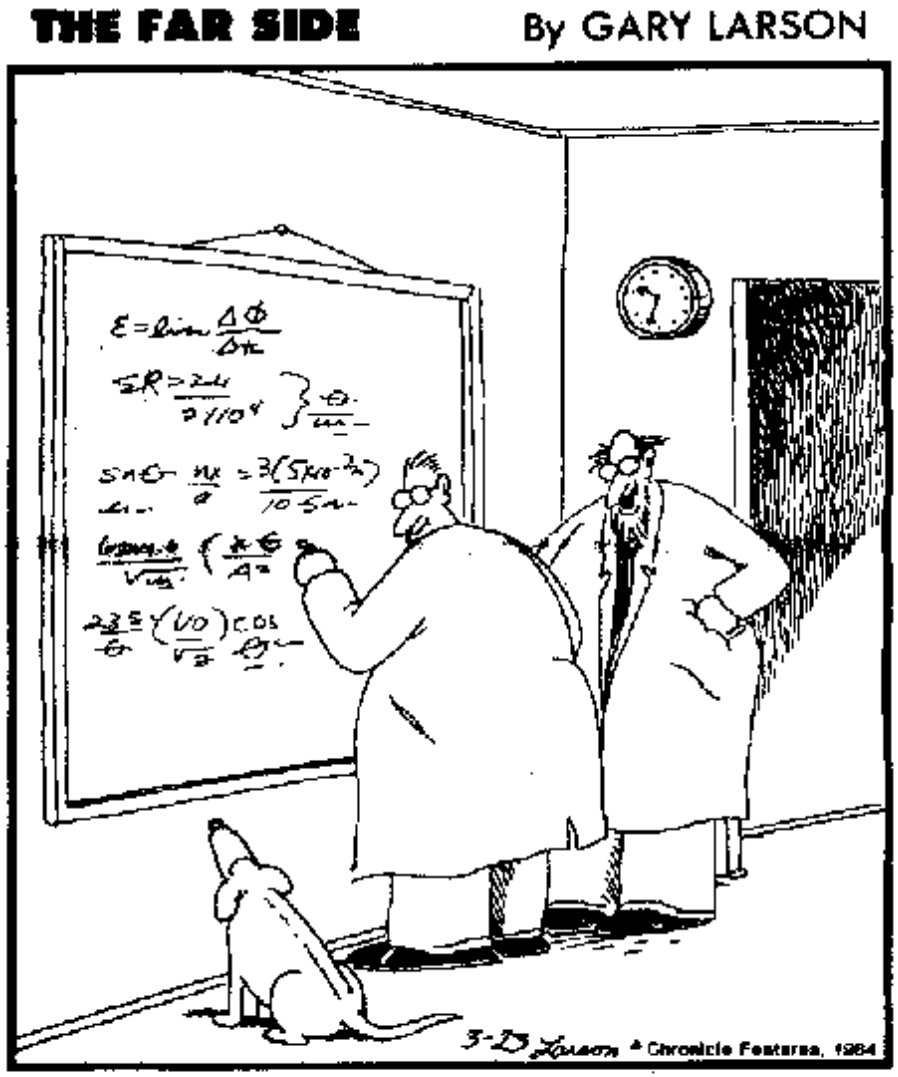
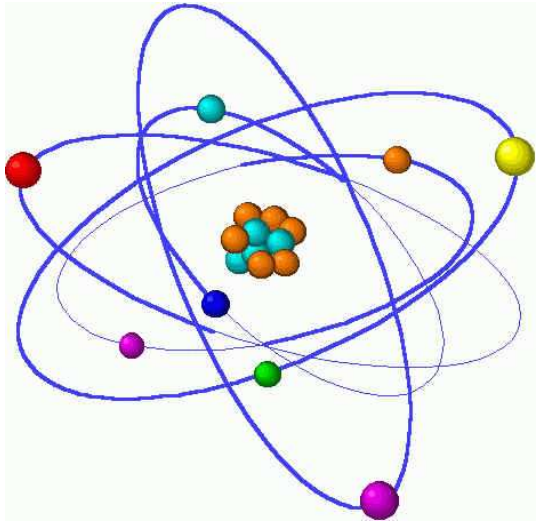



“Ohhhhhhh . . . Look at that, Schuster . . . Dogs are so cute when they try to comprehend quantum mechanics.”

# The Spectral Lines Problem



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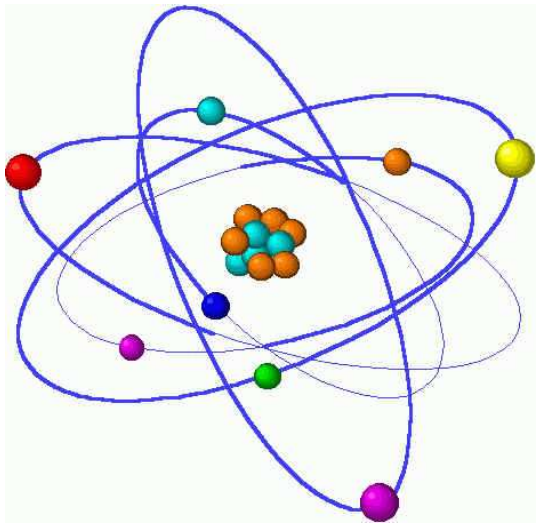

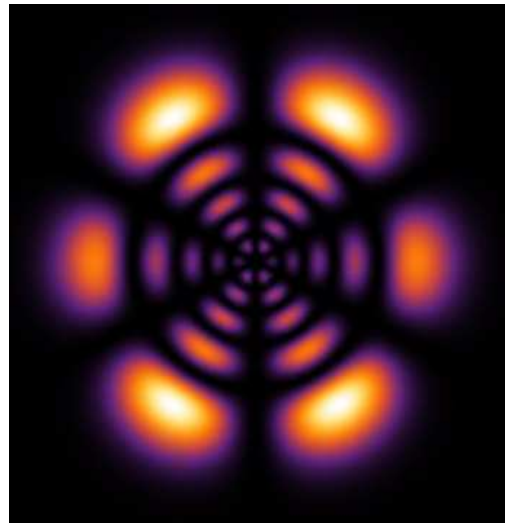

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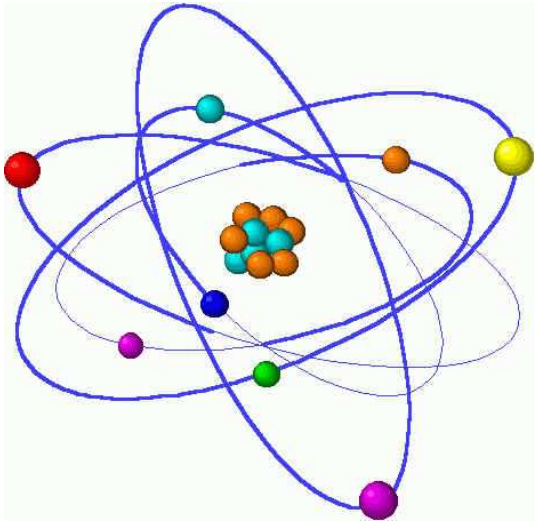
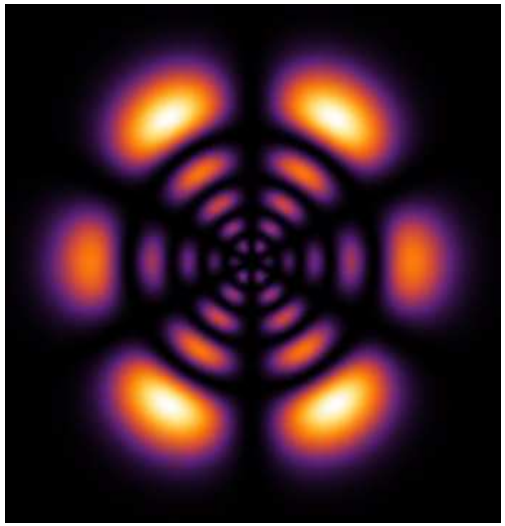
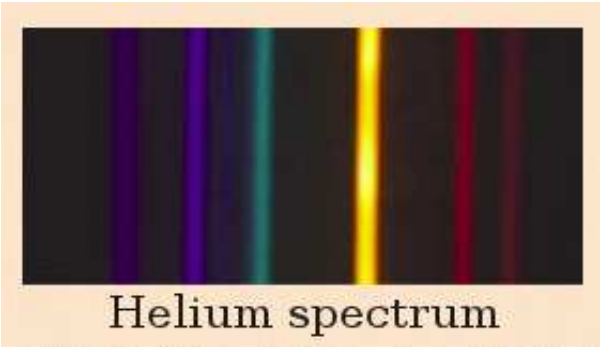
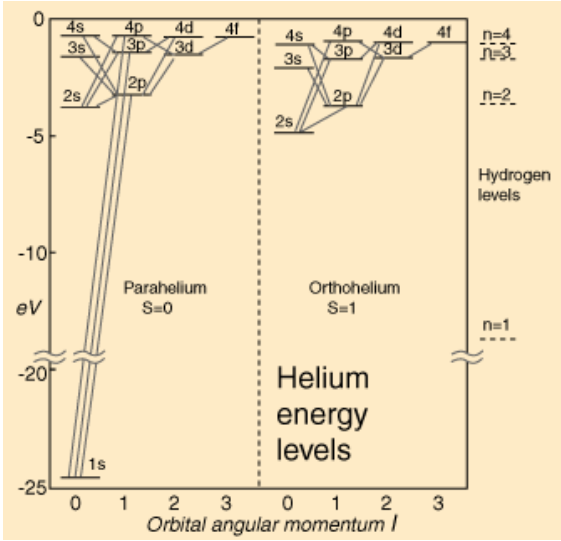
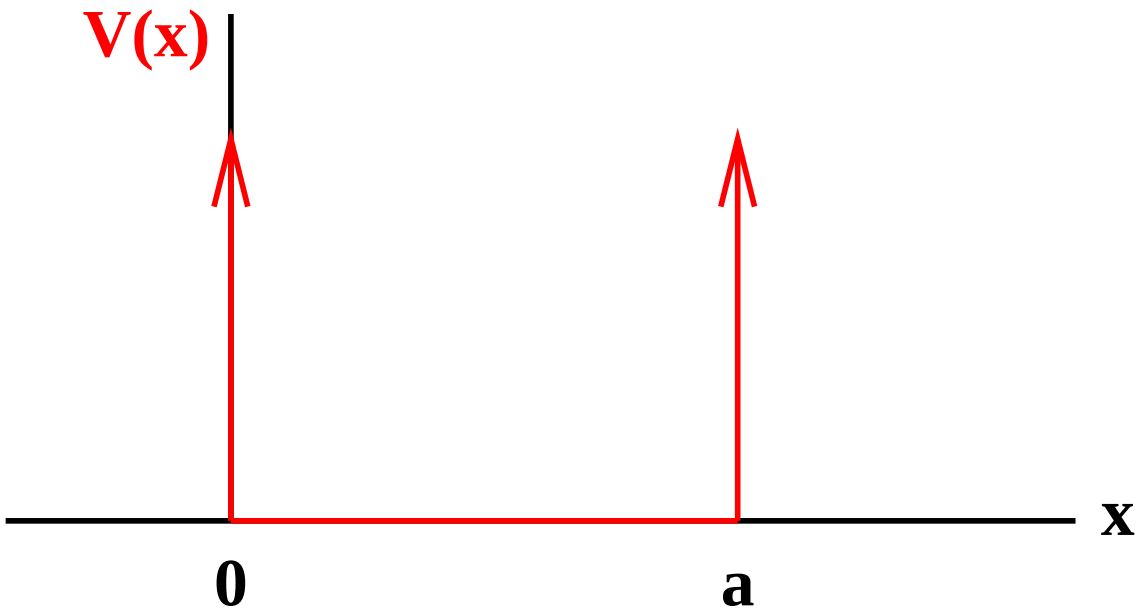






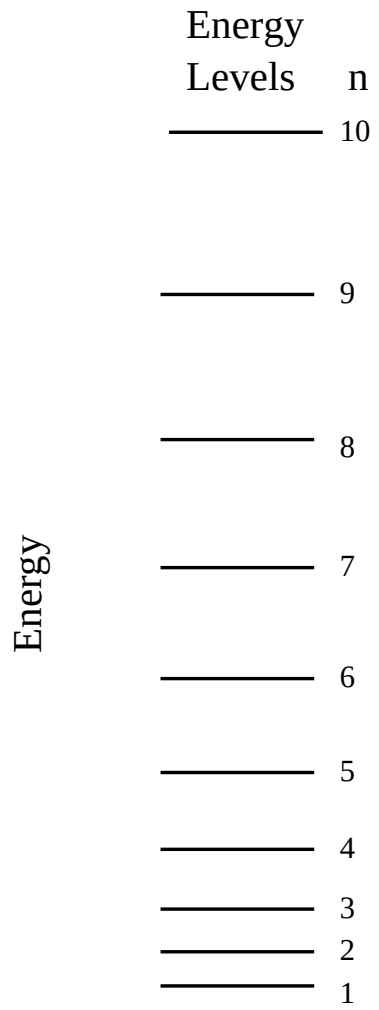
# A ‘Simple’ Example - Infinite Rectangular Well Potential




$$V(x) = 0 \quad 0 < x < a$$

$$= \infty \quad x \leq 0 \text{ and } x \geq a$$

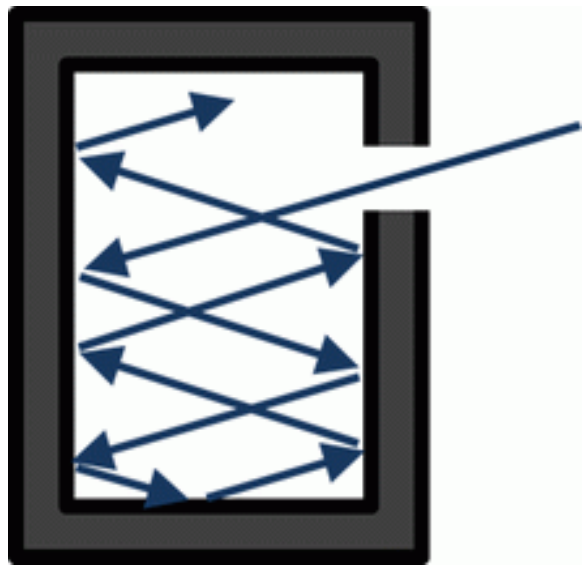
$$|n\rangle = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right) \qquad E_n = n^2 \frac{\hbar^2 \pi^2}{2ma^2}$$



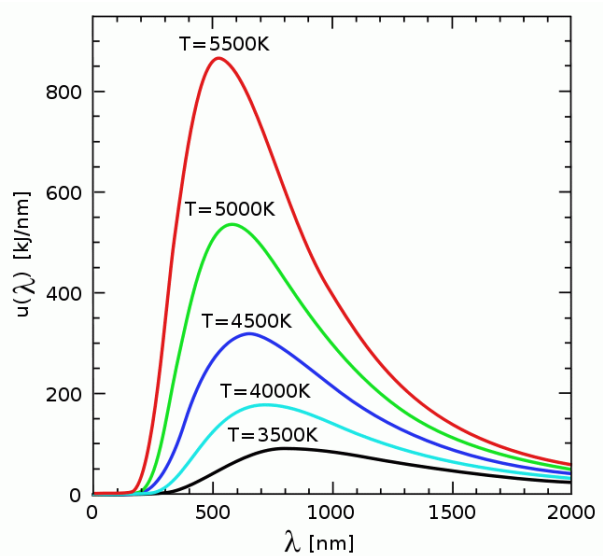
# Blackbody Radiation

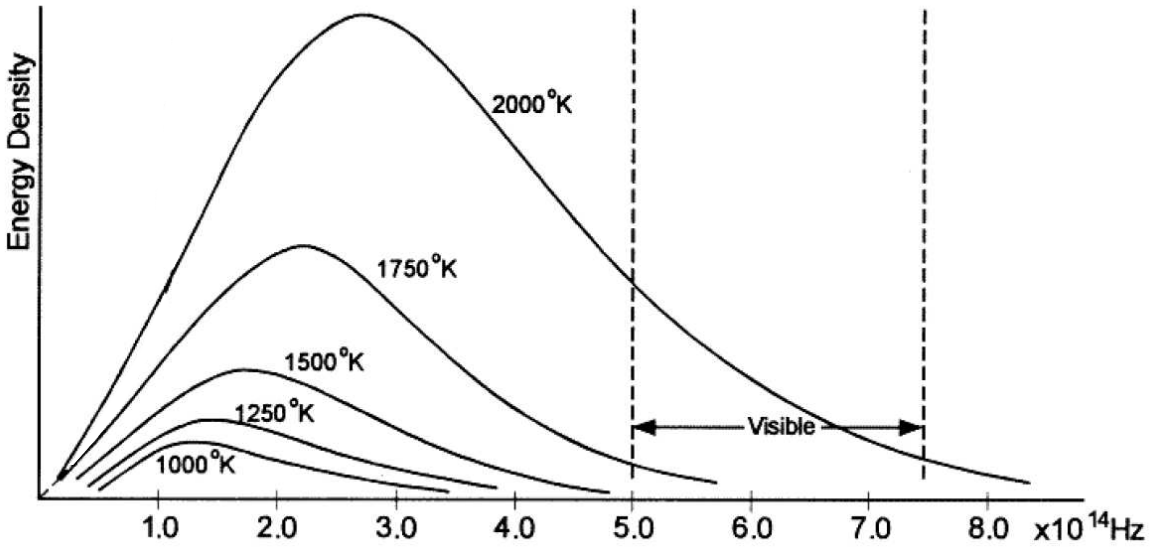
A black body is an idealized physical body that absorbs all incident electromagnetic radiation, regardless of frequency or angle of incidence. In thermal equilibrium (at a constant temperature) it emits electromagnetic radiation called black-body radiation with two notable properties.

1. It is an ideal emitter: it emits as much or more energy at every frequency than any other body at the same temperature.
2. It is a diffuse emitter: the energy is radiated isotropically, independent of direction.



# Measuring The Blackbody Radiation



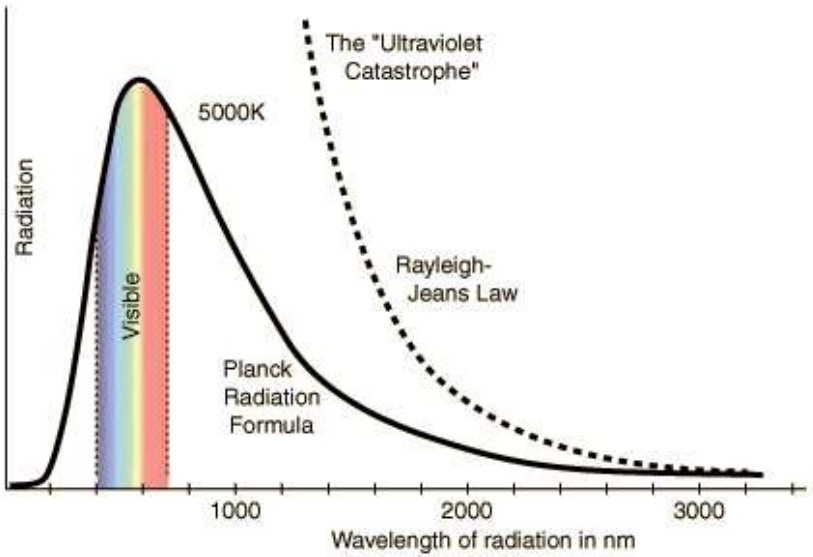



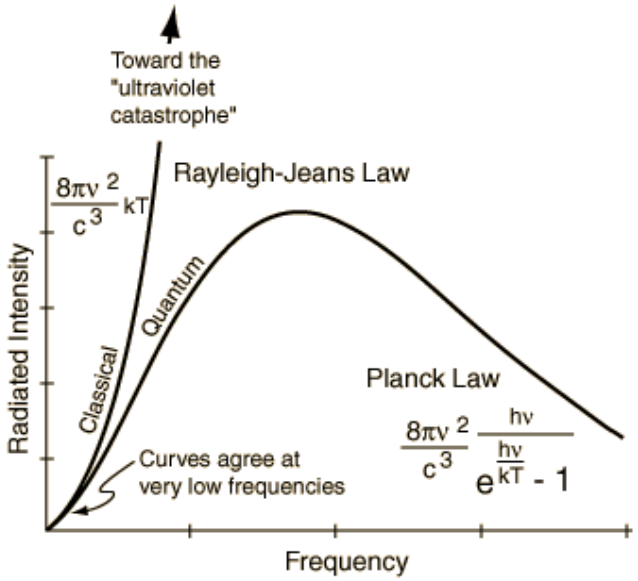

Visible light $\lambda \approx 400 - 700\ nm$

Measured by Lummer and Pringsheim (1899).

$$R_T(\nu)d\nu = \frac{\text{energy}}{\text{time-area}} \qquad \text{in the range } \nu \longrightarrow \nu + d\nu$$

# The Ultraviolet Catastrophe



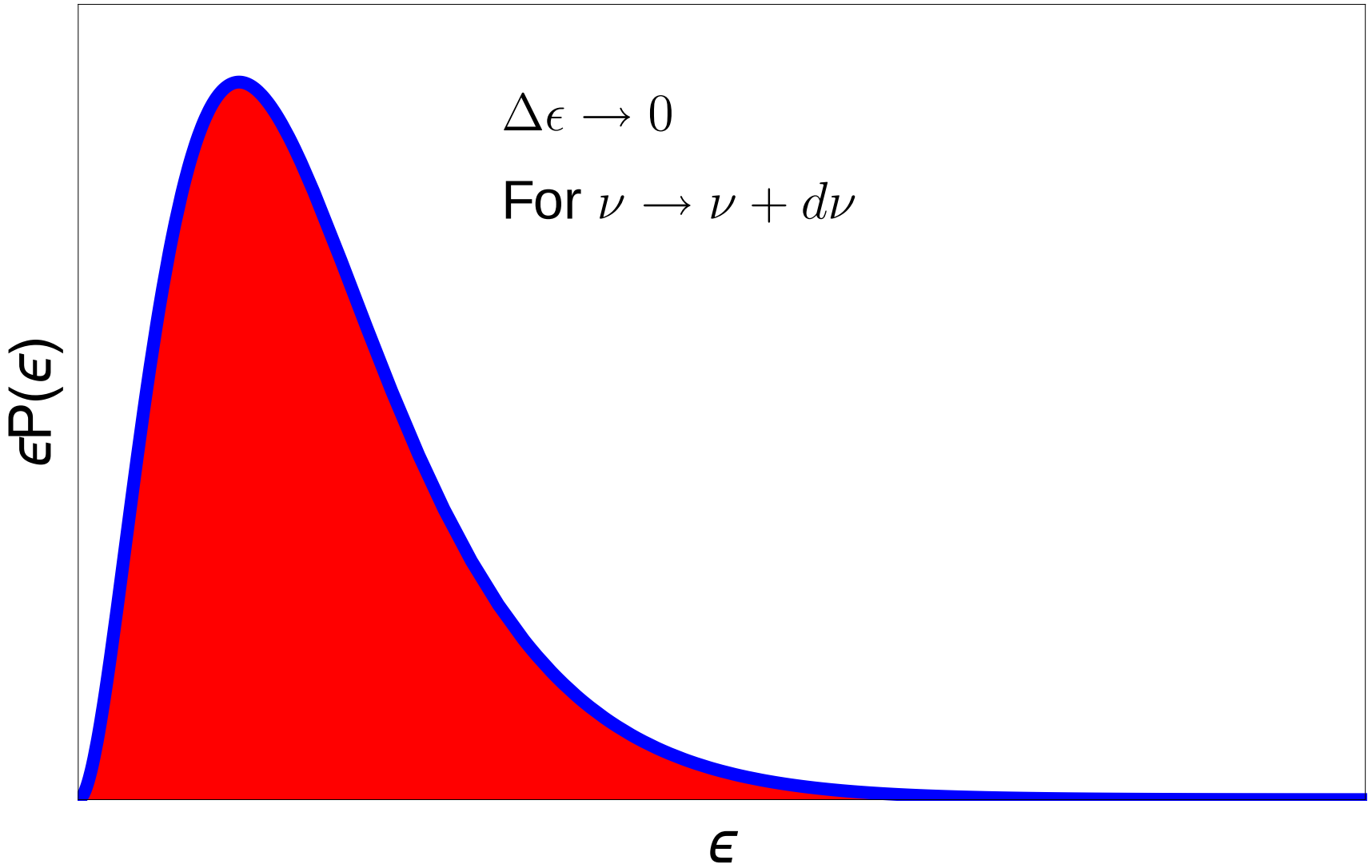




## Rayleigh-Jeans Law

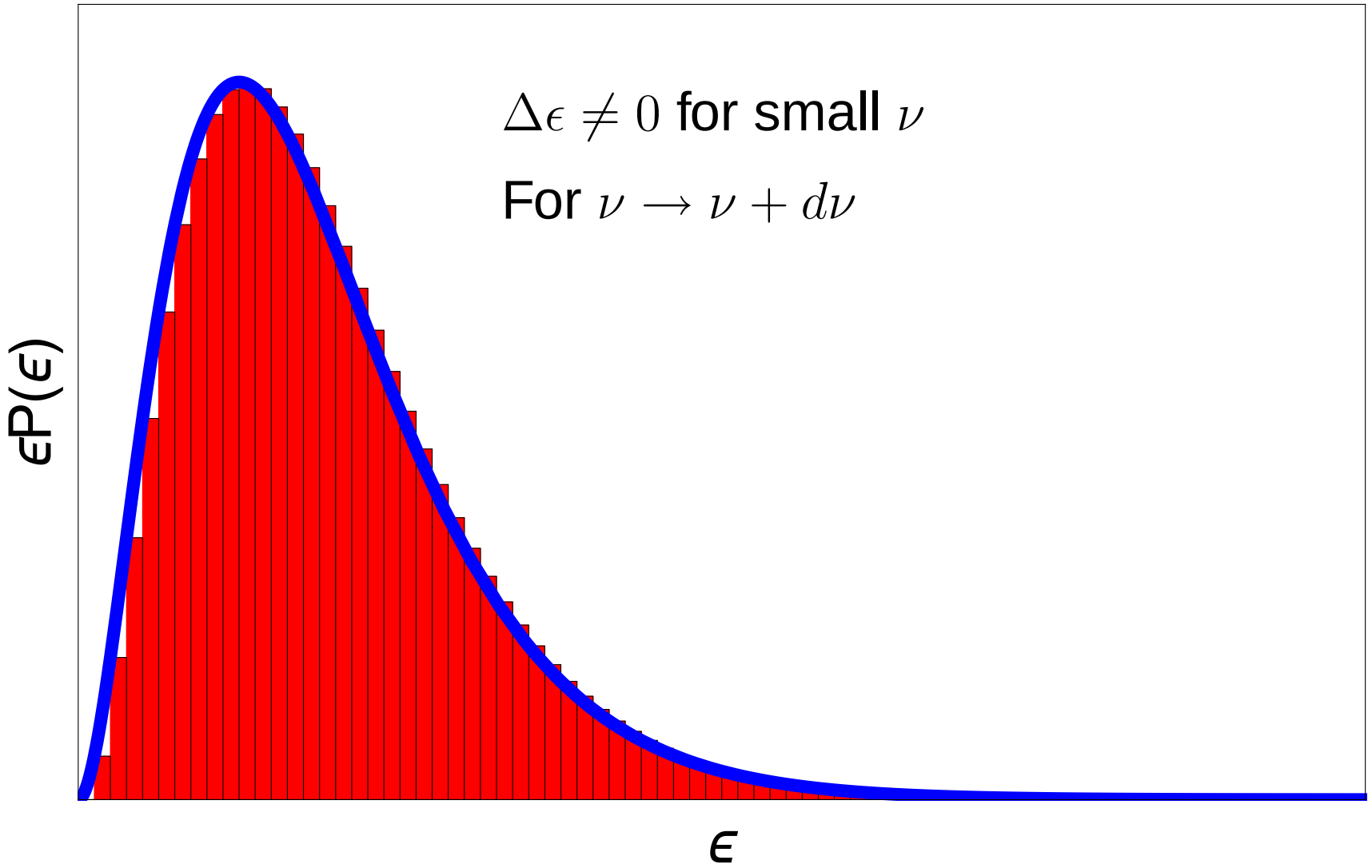
$$u(\nu)d\nu = \frac{8\pi}{c^3}k_B T\nu^2 d\nu \quad \text{in the range } \nu \longrightarrow \nu + d\nu$$

$T$ - temperature. $k_B$ - Boltzmann constant.

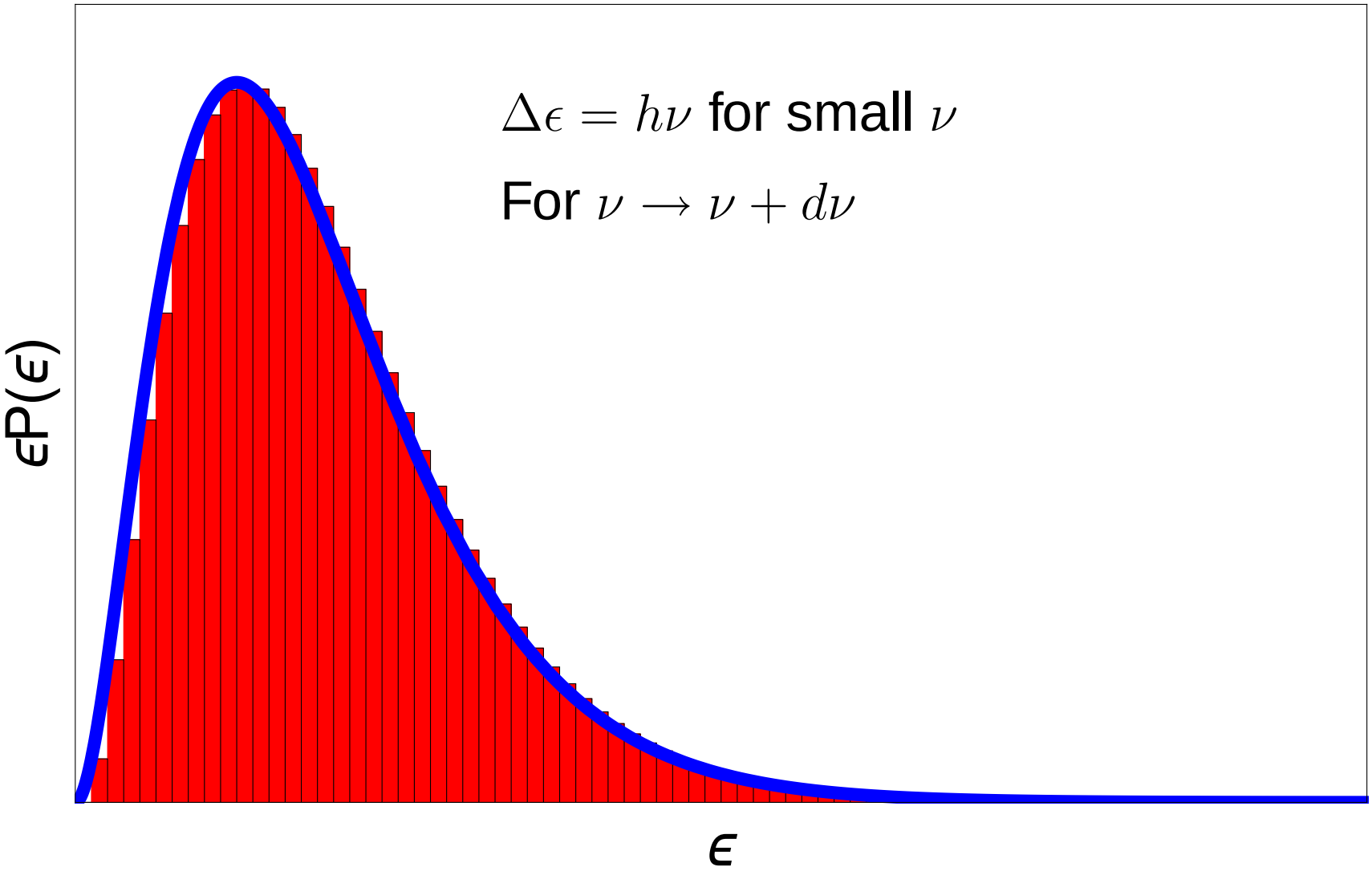
# Planck's Guess - the Boltzmann Distribution



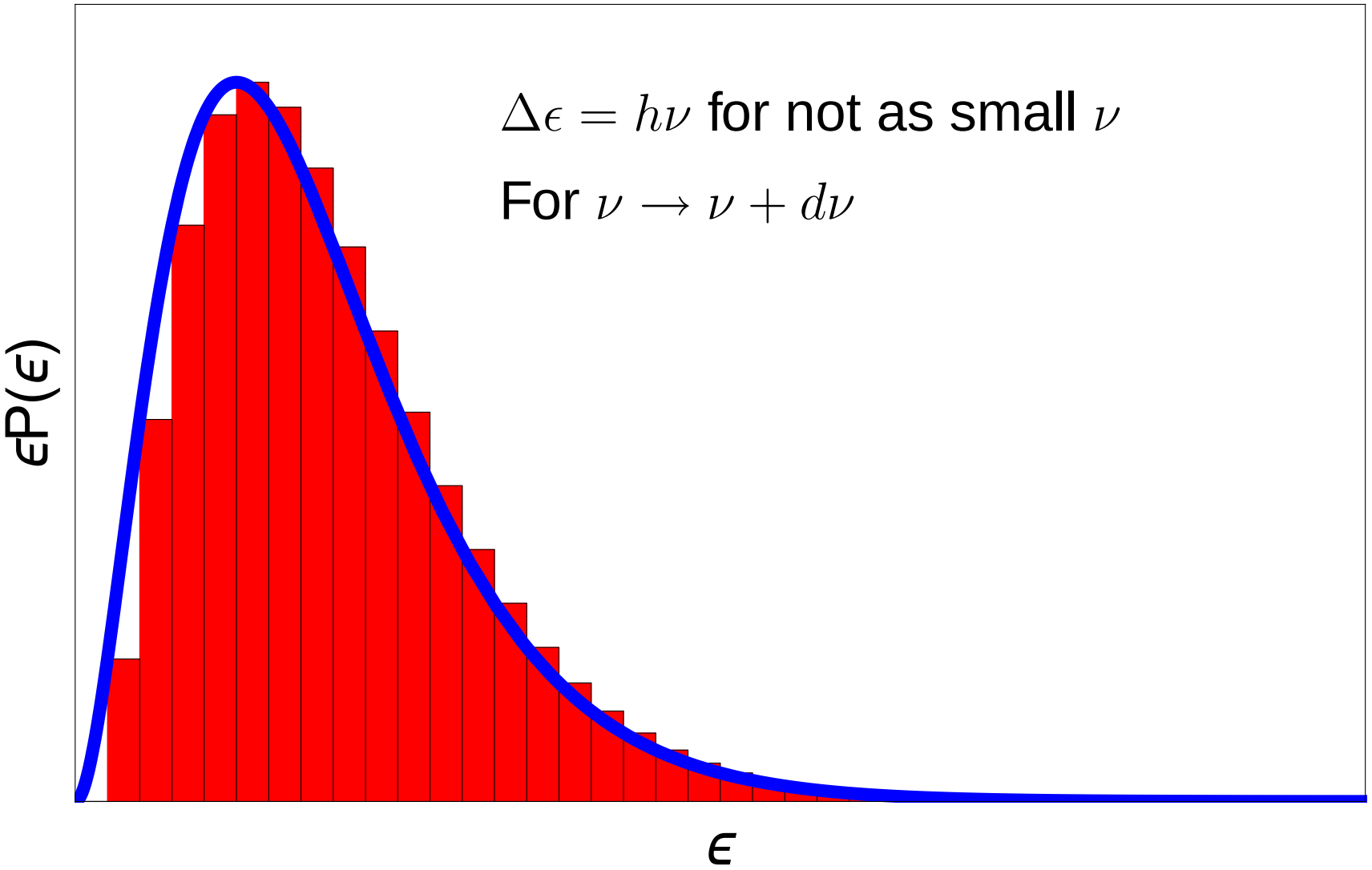
# Planck's Guess - Do a Riemannian Sum



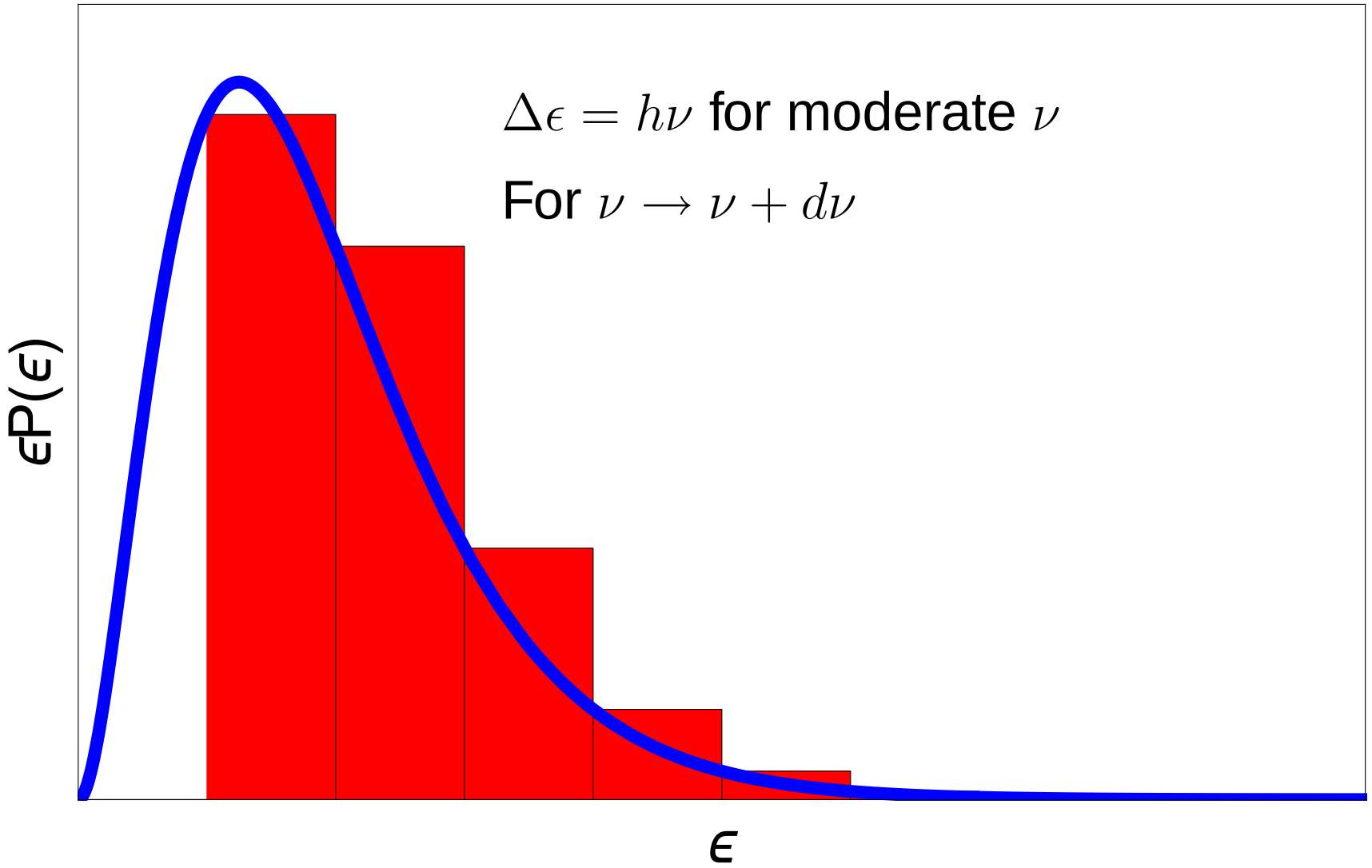
# Planck's Guess - Do a Riemannian Sum, low $\nu$



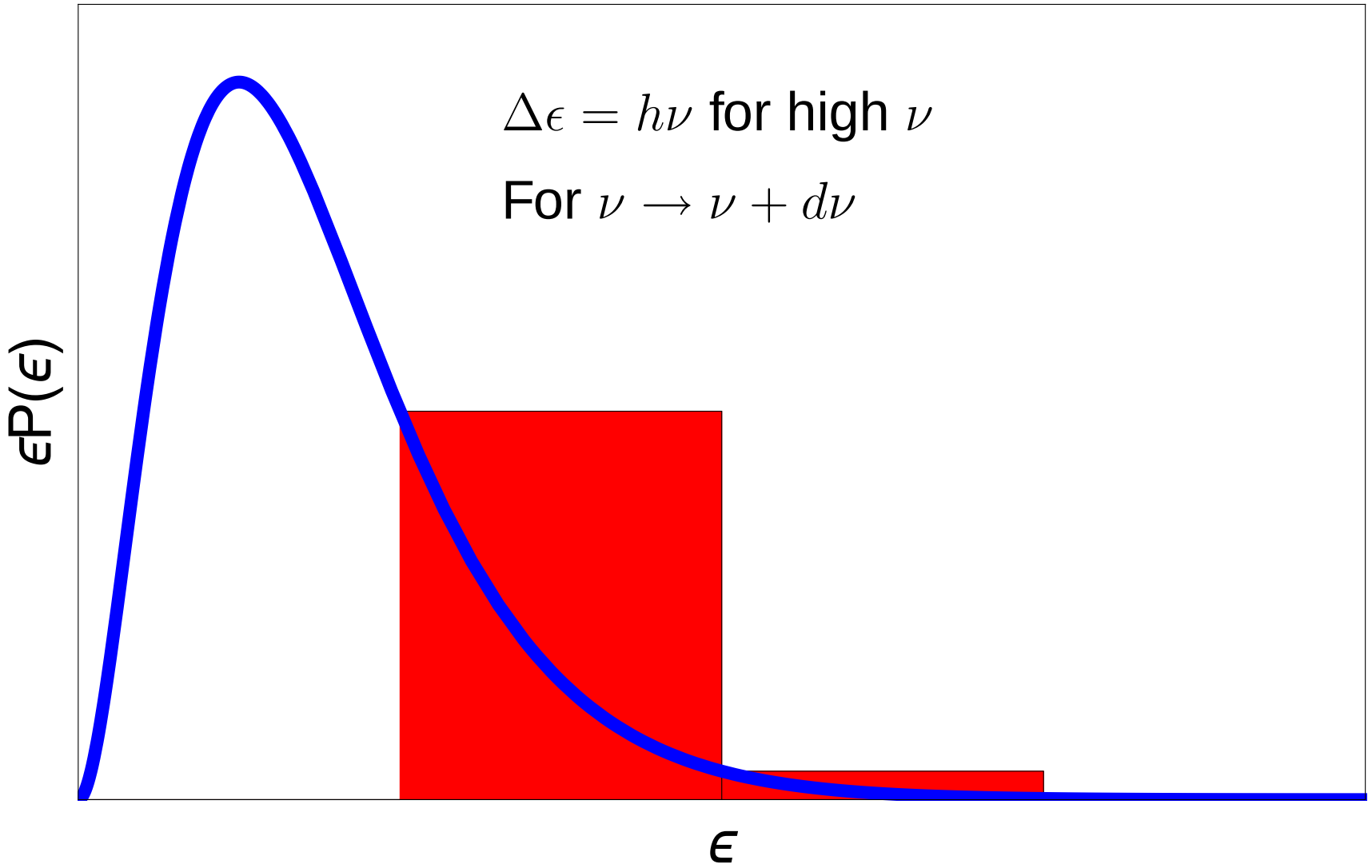
# Planck's Guess - Do a Riemannian Sum - not as lo



# Planck's Guess - Do a Riemannian Sum - moderate



# Planck's Guess - Do a Riemannian Sum - high $\nu$



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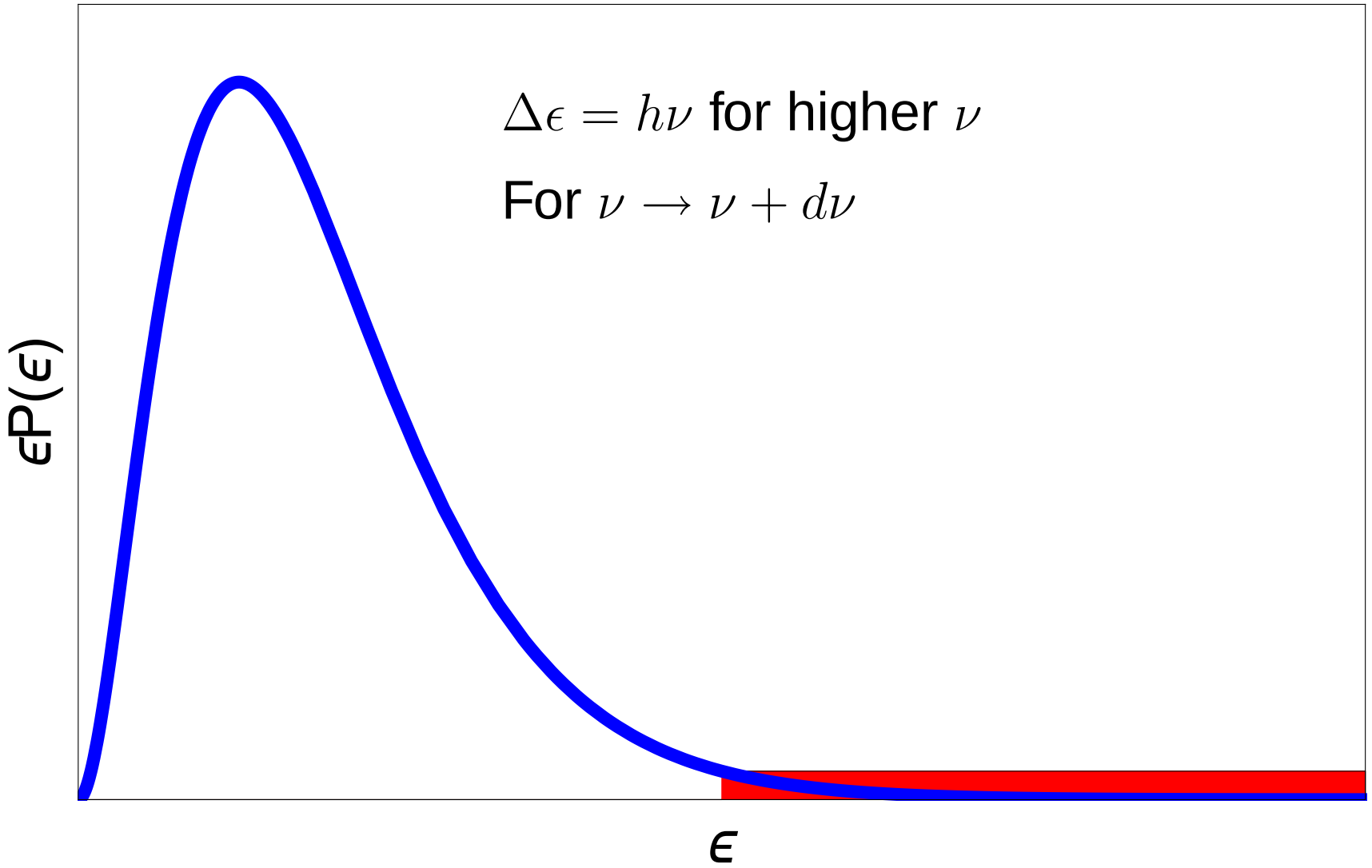

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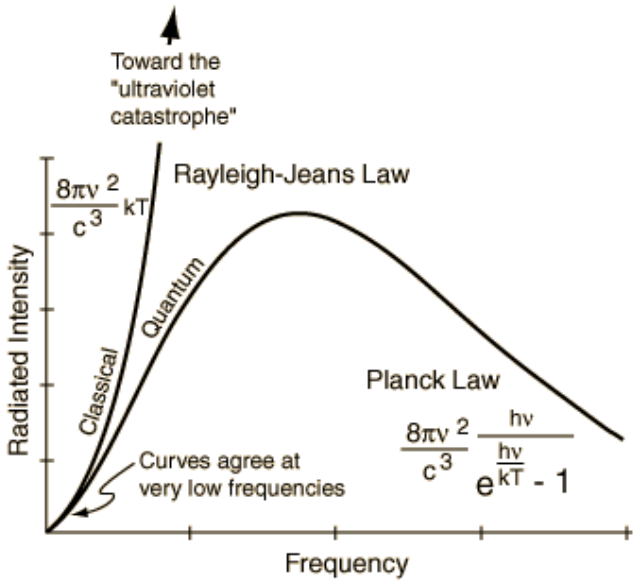


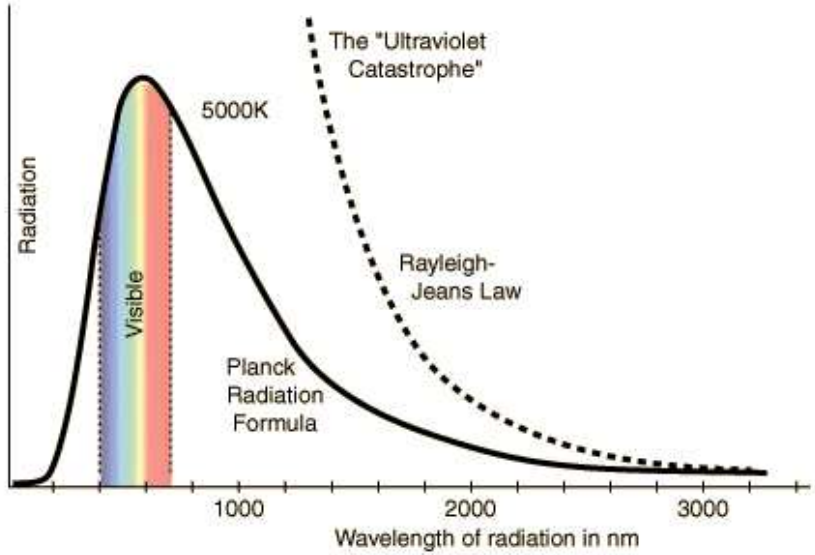


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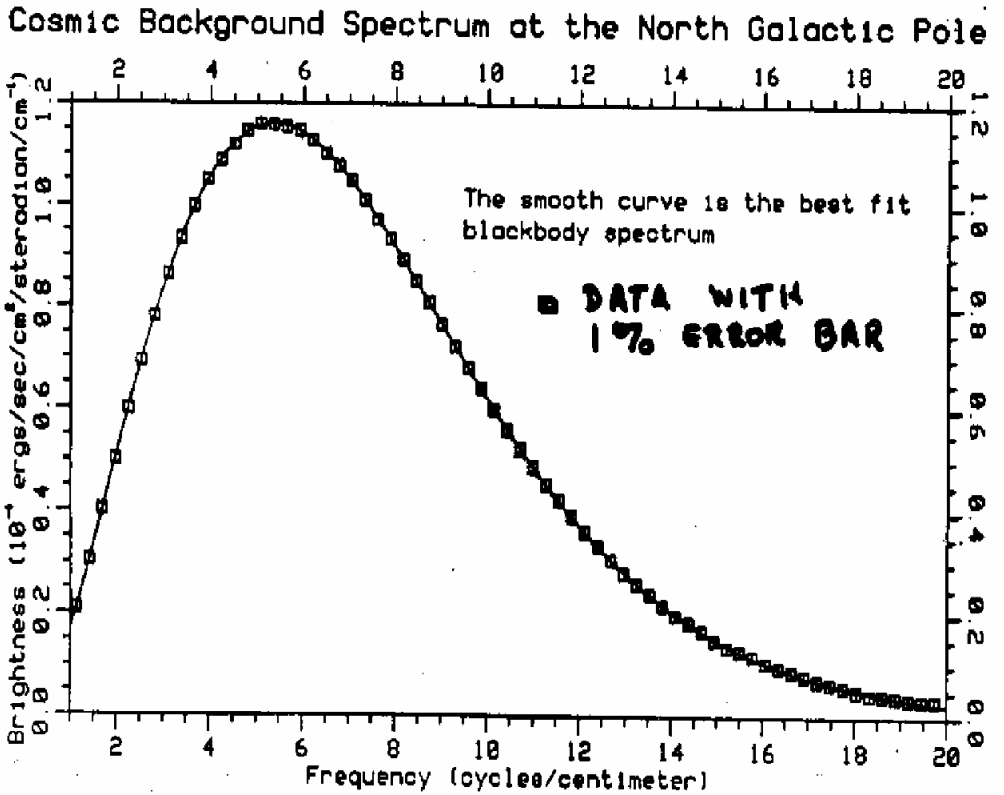


Scan of first showing of the COBE measurement of cosmic microwave background radiation at the American Astronomical Society meeting in January, 1990.

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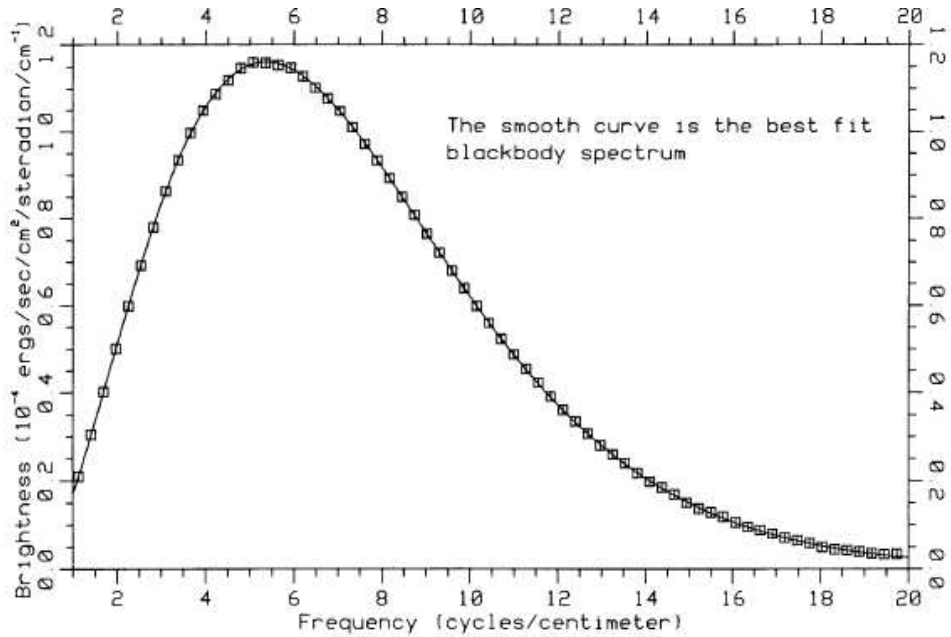


FIG. 2.—Preliminary spectrum of the cosmic microwave background from the FIRAS instrument at the north Galactic pole, compared to a blackbody. Boxes are measured points and show size of assumed 1% error band. The units for the vertical axis are $10^{-4}$ ergs $s^{-1}$ $cm^{-2}$ $sr^{-1}$ cm.

COBE measurement of the cosmic microwave background radiation from J.C Mather *et al.*, Astrophysical Journal *354*, L37-40 (1990).

# Other Mysteries That Needed Quantum Mechanics

- Photoelectric effect
- Compton effect
- Spectroscopy
- Davisson-Germer
- Radioactivity
- Nuclear sizes