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Einstein’s Reading of Planck

The heuristic of 1905 and the resonator of 1906

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Abstract. Einstein does not inherit a finished method from Planck and drop the word heuristic. In 1905 he puts the word in the title, works in the Wien limit rather than from Planck’s full law, and concludes that radiation behaves as if its energy were in localized quanta. In 1906 he argues that Planck’s count is justified only if resonator energies are integer multiples of $h\nu$. Admiration runs both ways and does not cancel the disagreement: Planck locates h at emission and absorption and keeps Maxwell in the vacuum; Einstein treats the quantum as real and still does not possess an individual law of the emission instant. That second gap is the one open in 1949.

1. 1905

“Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt,” *Annalen der Physik* 17 (1905) 132. The viewpoint is called heuristic in the title. He is not claiming the dynamics of one emission. He is claiming that, for the production and transformation of light, a picture at odds with a continuous Maxwellian distribution works, while diffraction and interference remain with the wave theory.

He uses the Wien regime, where the spectral density falls exponentially and Planck’s formula agrees with Wien’s. The entropy of that radiation, as a function of volume at fixed energy, matches the entropy of an ideal gas of independent particles whose energy is proportional to frequency. In modern notation the proportionality is $h\nu$. Monochromatic radiation in that regime behaves thermodynamically as if it consisted of mutually independent energy quanta of that size.

The introduction states the picture that follows: the energy of a ray from a point is not spread continuously over a growing volume, but consists of a finite number of energy quanta, localized in space, moving without dividing, absorbed or generated only as wholes. The applications are photoluminescence, the photoelectric effect, and ionization. For the photoelectric effect the maximum kinetic energy of the freed electron is the quantum minus the work of leaving the metal. Intensity does not set that maximum. Frequency does.

In May 1905 he wrote to Conrad Habicht that this paper was very revolutionary. That is his ranking of it among the papers of the year, at the time.

He does not say that classical methods were tried on the photoelectric effect, failed, and that he therefore borrowed Planck’s device. He says the entropy in the Wien limit already has the form of a gas of quanta, and that several conversion phenomena are readable in that form. Planck’s full derivation is something he is not yet willing to use.

2. 1906

“Zur Theorie der Lichterzeugung und Lichtabsorption,” *Annalen der Physik* 20 (1906) 199. Here he stops setting Planck’s law aside. The claim is that the combinatorial step is justified if a resonator of frequency ν can possess only the energies $0, h\nu, 2h\nu, \ldots$. Emission and absorption exchange whole quanta. The basis is not Maxwell’s. He adds, as an assumption he marks, that the average energy of the resonator is nevertheless the average Maxwell’s theory would give. From that average, restricted to the discrete set, Planck’s formula follows.

This is the point at which Einstein uses h intentionally as a physical restriction on the individual resonator, rather than as Planck's formal chopping of a total energy. It is a reading of the 1900 count, not a transcription of a method Planck had offered as classical. Planck had hoped the element was a counting device. Einstein says the device is doing physical work, and that the classical count was not actually available.

3. What Planck and others answered

Planck to Einstein, 6 July 1907: he looks for the meaning of the quantum of action at absorption and emission, not in the vacuum, and he takes the vacuum to be described by Maxwell's equations. Laue to Einstein, June 1906, draws the same line. Quanta at the exchange with matter are one claim. Light quanta as constituents of radiation in empty space are another, and Laue refuses the second.

In 1913 Planck, Nernst, Rubens, and Warburg recommend Einstein to the Prussian Academy in language that praises the achievement and notes that he may sometimes have missed the target, the hypothesis of light quanta being the example. The admiration is documented. So is the refusal. They are not evidence that Planck recognized Einstein as the disciple who completed a heuristic Planck had modestly begun. Planck thought Einstein had gone past the evidence. Einstein thought Planck had already left the classical theory and had not admitted the departure.

4. What neither paper contains

Neither the heuristic viewpoint nor the 1906 resonator argument says when a given quantum leaves a given system. The 1905 paper is explicit that the wave account of interference stands. The 1906 paper justifies a mean energy. Einstein's 1916–17 coefficients will make the time of emission a probability per unit time, and he will not like the probability. The 1949 Reply still uses the radioactive mark as the example of a fact the statistical theory does not describe. Taking h to be real, which he does from 1906 onward, is not the same act as possessing the individual law. The first act is done in these papers. The second is not.

The suggestion that Einstein merely deployed, on purpose, a guess Planck had used because classical methods were exhausted, is half right. Classical equipartition does not give the spectrum, and Planck's element is the cost of a count that does. Einstein is the one who treats that cost as physical. He is also the one who calls his own 1905 argument heuristic, and he does not, in these years, replace either Maxwell or Boltzmann with a continuous field whose solutions emit at definite times.

5. What he added before 1949

The 1905 entropy match is only the Wien regime. In 1907, *Annalen der Physik* 22, 180, the same oscillator mean energy is put into a solid. Dulong and Petit's $3R$ is equipartition. It fails at low temperature because $U = h\nu/\left(e^{h\nu/kT} - 1\right)$ freezes the oscillator out. That paper is what made h a fact about matter for Nernst, not only a fact about cavities. It is still a mean.

In 1909 the energy fluctuation of blackbody radiation in a subvolume splits, if Planck's law is used, into a particle term $h\nu \cdot E$ and a wave term proportional to E^2. *Physikalische Zeitschrift* 10 (1909) 185. He does not claim a picture that owns both.

In 1917, *Physikalische Zeitschrift* 18, 121, three coefficients A_{21}, B_{21}, and B_{12} recover Planck's law from detailed balance, and each quantum carries momentum $h\nu/c$. The weakness he names is the one the Reply will still name: the instant and the direction of spontaneous emission are left to chance. The History tab follows that admission through Bohr, the matrix camp, the wave camp, and the later interpretations. None of them closes it by a local individual law. The calculations of the photoelectric line and of Brownian motion are a different site paper, *Four Calculations, 1904–1905*. They are not repeated here.

6. References

1. A. Einstein, "Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt," *Annalen der Physik* 17, 132–148 (1905).

2. A. Einstein, “Zur Theorie der Lichterzeugung und Lichtabsorption,” *Annalen der Physik* 20, 199–206 (1906).
3. A. Einstein to C. Habicht, May 1905. *Collected Papers of Albert Einstein*.
4. M. Planck to A. Einstein, 6 July 1907. *Collected Papers of Albert Einstein*.
5. M. von Laue to A. Einstein, June 1906. *Collected Papers of Albert Einstein*.
6. M. Planck, W. Nernst, H. Rubens, and E. Warburg, recommendation of Einstein to the Prussian Academy, 12 June 1913.
7. A. Einstein, “Die Plancksche Theorie der Strahlung und die Theorie der spezifischen Wärme,” *Annalen der Physik* 22, 180–190 (1907).
8. A. Einstein, “Zum gegenwärtigen Stand des Strahlungsproblems,” *Physikalische Zeitschrift* 10, 185–193 (1909).
9. A. Einstein, “Zur Quantentheorie der Strahlung,” *Physikalische Zeitschrift* 18, 121–128 (1917).
10. A. Einstein, “Reply to Criticisms,” in P. A. Schilpp (ed.), *Albert Einstein: Philosopher-Scientist* (1949).
11. W. Shields, “Four Calculations, 1904–1905” (2026). Site paper. The algebra this essay does not repeat.

Not a Zenodo deposit. Read with the Planck paper and with Shields 2026c. Does not replace 2026a or 2026b.