

Resonant Coupling of $\sim 3 \mu\text{m}$ Radiant Flux to Hydroxyl Stretch Modes in Crumb

(unattributed)

Abstract. The element of the apparatus must glow. We show why it must glow at a particular colour: a wire near 700°C emits most strongly near $3 \mu\text{m}$, where the O–H stretching vibration of water absorbs most strongly, so that the radiant flux is taken up in the outermost layer of the matrix, where the water is and where browning must occur. We set out the radiant flux from Stefan and Boltzmann and its distribution from Planck, and we dispose, again, of the peasant scorch.

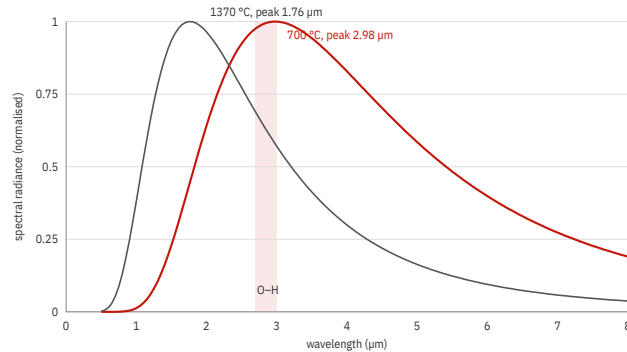


Figure 1. Normalised spectral radiance of a black body at 700°C and at 1370°C , the temperature at which a 14 g platinum element settles (PA/Cy07/0058, Table 2). The shaded band, 2.7 to $3.0 \mu\text{m}$, is the O–H stretching absorption of water.

1 THE DOCTRINE

It is the doctrine of the Academy that the element shall stand at 700°C . The doctrine has been costly (PA/Cy07/0058, erratum). This paper sets out its grounds.

2 HOW MUCH THE ELEMENT RADIATES

A surface of area A , emissivity ε and temperature T facing a cooler surface at T_s exchanges radiant power

$$P = \varepsilon \sigma A (T^4 - T_s^4), \quad \sigma = 5.670 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}. \quad (1)$$

The fourth power is the whole of the matter: a modest rise in the temperature of the wire multiplies its flux, and a wire that cannot shed its power at one temperature will find another, hotter one at which it can.

3 AT WHAT COLOUR

Planck's law [1] gives the distribution of that flux over wavelength. Its maximum lies at

$$\lambda_{\text{max}} = \frac{b}{T}, \quad b = 2897.8 \mu\text{m K}, \quad (2)$$

the displacement law of Wien. At 700°C (973 K), $\lambda_{\text{max}} = 2.98 \mu\text{m}$. The visible glow of the wire, which the Host finds beautiful, is the short-wavelength tail of an emission that lies almost wholly in the infrared.

4 WHERE THE FLUX IS ABSORBED

Liquid water absorbs most strongly in the infrared near $3 \mu\text{m}$, at its O–H stretching fundamentals, with an absorption coefficient there of order 10^4 cm^{-1} [2]: such light is extinguished

within a few micrometres. Flux near $3 \mu\text{m}$ is therefore taken up at the very surface of a moist matrix, which is where the evaporative plateau must be cleared and where browning must occur (PA/Cy05/0031). The Academy calls this resonant coupling. The vibrational absorption of a molecular bond is, properly, a resonance; the term is used with care.

The emission peak leaves the band at $2.7 \mu\text{m}$ when $T = b/2.7 \mu\text{m} = 1073 \text{ K}$, that is, 800°C . A wire run hotter, to spare platinum, emits at shorter wavelengths, which water absorbs less strongly and which therefore penetrate further and heat the interior before the surface. A weaker water band near $1.9 \mu\text{m}$ is acknowledged. It is not the doctrine.

5 THE PEASANT SCORCH

Matrix held before an open hearth has been browned on this worldline and on ours since antiquity. The hearth radiates from one side only; its coals and flames are of no single temperature; it deposits soot and smoke; and the operator must turn the matrix by hand and by judgement. The result is browned. It is not uniform, it is not bilateral, and it is not uniform toast. The Academy does not count it.

6 CONCLUSION

The element must glow, because a wire hot enough to be seen is hot enough to deliver the necessary flux; and it must glow dull red, near 700°C , because there its emission falls where water drinks it. The doctrine stands.

TO CONVERGENTS

Convergents holding findings, contrary results or papers bearing on this matter are implored to publish them. The Academy will find them. No such publication has yet been found.

REFERENCES

- [1] M. Planck, Über das Gesetz der Energieverteilung im Normalspektrum, *Annalen der Physik* 309 (1901) 553–563.
- [2] G. M. Hale, M. R. Querry, Optical constants of water in the 200-nm to 200- μm wavelength region, *Applied Optics* 12 (1973) 555–563.
- [3] F. P. Incropera, D. P. DeWitt, T. L. Bergman, A. S. Lavine, *Fundamentals of Heat and Mass Transfer*, 6th ed., Wiley, 2007.
- [4] The Academy, PA/Cy05/0031, The Evaporative Plateau.
- [5] The Academy, PA/Cy07/0058, The Platinum Doctrine.