① $x^3 - 12x^2 + 45x = 104$

(a) $x^3 - 12x^2 + 45x - 104 = 0$

Erste Nullstelle: $x = 8$

$$\begin{array}{l} (x^3 - 12x^2 + 45x - 104) : (x - 8) = x^2 - 4x + 13 \\ -(x^3 - 8x^2) \\ \quad -4x^2 + 45x \\ \quad -(-4x^2 + 32x) \\ \qquad 13x - 104 \\ \qquad -(13x - 104) \\ \qquad\qquad 0 \end{array}$$

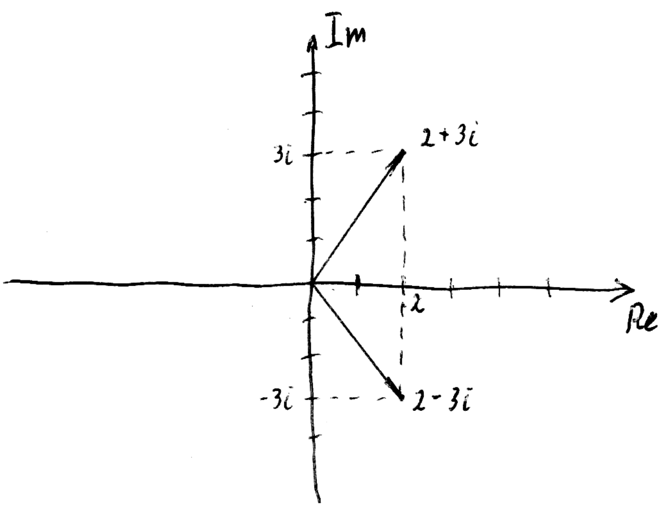
$(x-8)(x^2 - 4x + 13) = 0$

$x^2 - 4x + 13 = 0$

$D = 16 - 52 = -36$

$x_{1,2} = \dfrac{4 \pm \sqrt{-36}}{2} = \dfrac{4 \pm 6\sqrt{-1}}{2} = 2 \pm 3i$

(b)



$|x| = \sqrt{(2+3i)(2-3i)} =$

$= \sqrt{4+9} = \sqrt{13}$

$\varphi_x = \arctan \dfrac{Im(x)}{Re(x)}$

$\varphi_{1,2} = \arctan\left(\pm \dfrac{3}{2}\right) = (\pm 56{,}31) =$

$= \pm 0{,}9823$

$x_{1,2} = \sqrt{13}\, e^{\pm i \cdot 0{,}9823}$

(c) $x_1 = x_2^*$

$x_2 = x_1^*$

(d) $s = 8 + 6i$

$t = 4e^{i\frac{\pi}{2}} = 4\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right) = 4i$

$t \cdot s = 4i(8 + 6i) = -24 + 32i$

$\frac{s}{t} = \frac{8+6i}{4i} = -\frac{8i - 6}{4} = \frac{6 - 8i}{4} = \frac{3}{2} - 2i$

$t^* = -4i$

$\frac{t}{s} = \frac{4i}{8+6i} = \frac{4i(8-6i)}{(8+6i)(8-6i)} = \frac{32i + 24}{64 - 36} = \frac{24 + 32i}{28} = \frac{6 + 8i}{7}$

② (a) $\lambda = 589\ nm$

$16978\ cm^{-1}$

$3{,}37862 \cdot 10^{-19}\ J$

$2{,}10527\ eV$

$0{,}077419\ H$

Einheit	cm^{-1}	J	eV	H
$1\ cm^{-1}$	1	$1.99 \cdot 10^{-23}$	$1.24 \cdot 10^{-4}$	$4.56 \cdot 10^{-6}$
$1\ J$	$5.04 \cdot 10^{22}$	1	$6.24 \cdot 10^{18}$	$2.29 \cdot 10^{17}$
$1\ eV$	8066	$1.6 \cdot 10^{-19}$	1	$3.67 \cdot 10^{-2}$
$1\ H$	$2.2 \cdot 10^{5}$	$4.36 \cdot 10^{-18}$	27.2	1

(b) $P_{elekt} = 150\ W$

$$\frac{P_{Licht}}{P_{elekt}} = 0{,}5 \Rightarrow P_{Licht} = 75\ W$$

Plank: $E = nh\nu = nh\frac{c}{\lambda}$

$$P = \frac{E}{t} = \frac{nhc}{\lambda t}$$

$$n = \frac{P \cdot \lambda \cdot t}{hc} = \frac{75\ W \cdot 589 \cdot 10^{-9}\ m \cdot 1\ s}{6{,}626 \cdot 10^{-34}\ Js \cdot 3 \cdot 10^{8}\ \frac{m}{s}}$$

$$n = 22{,}223 \cdot 10^{19}$$

(c) $$30\ \frac{ct}{kWh} = 8{,}33 \cdot 10^{-6}\ \frac{ct}{J}$$

Das Energieäquivalent von 1g Photonen:

$$E_{phot} = m \cdot c^2 = 1 \cdot 10^{-3}\ kg \cdot c^2 = 8{,}9875 \cdot 10^{13}\ J$$

$\Rightarrow$ Preis von 1g Photonen: $8{,}9875 \cdot 10^{13}\ J \cdot 8{,}33 \cdot 10^{-6}\ \frac{ct}{J} \approx 7{,}49$ Mio €

③ Plancksches Strahlungsgesetz

$$u(\omega) = \frac{\omega^2}{\pi^2 c^3} \frac{\hbar\omega}{e^{\frac{\hbar\omega}{kT}} - 1}$$

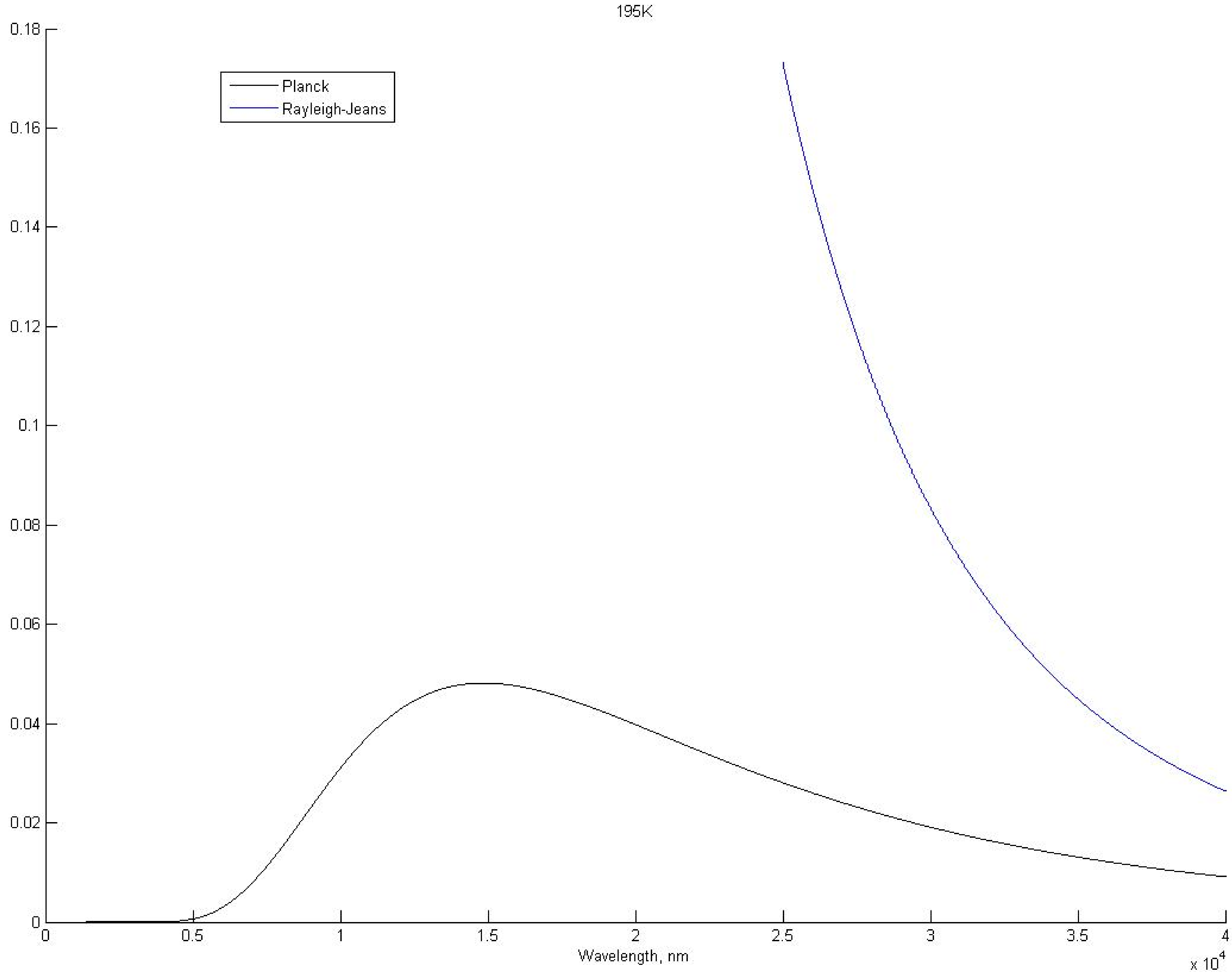
$$\exists \ \frac{\hbar\omega}{kT} \ll 1 \Rightarrow e^{\frac{\hbar\omega}{kT}} - 1 \approx 1 + \frac{\hbar\omega}{kT} - 1 = \frac{\hbar\omega}{kT}$$

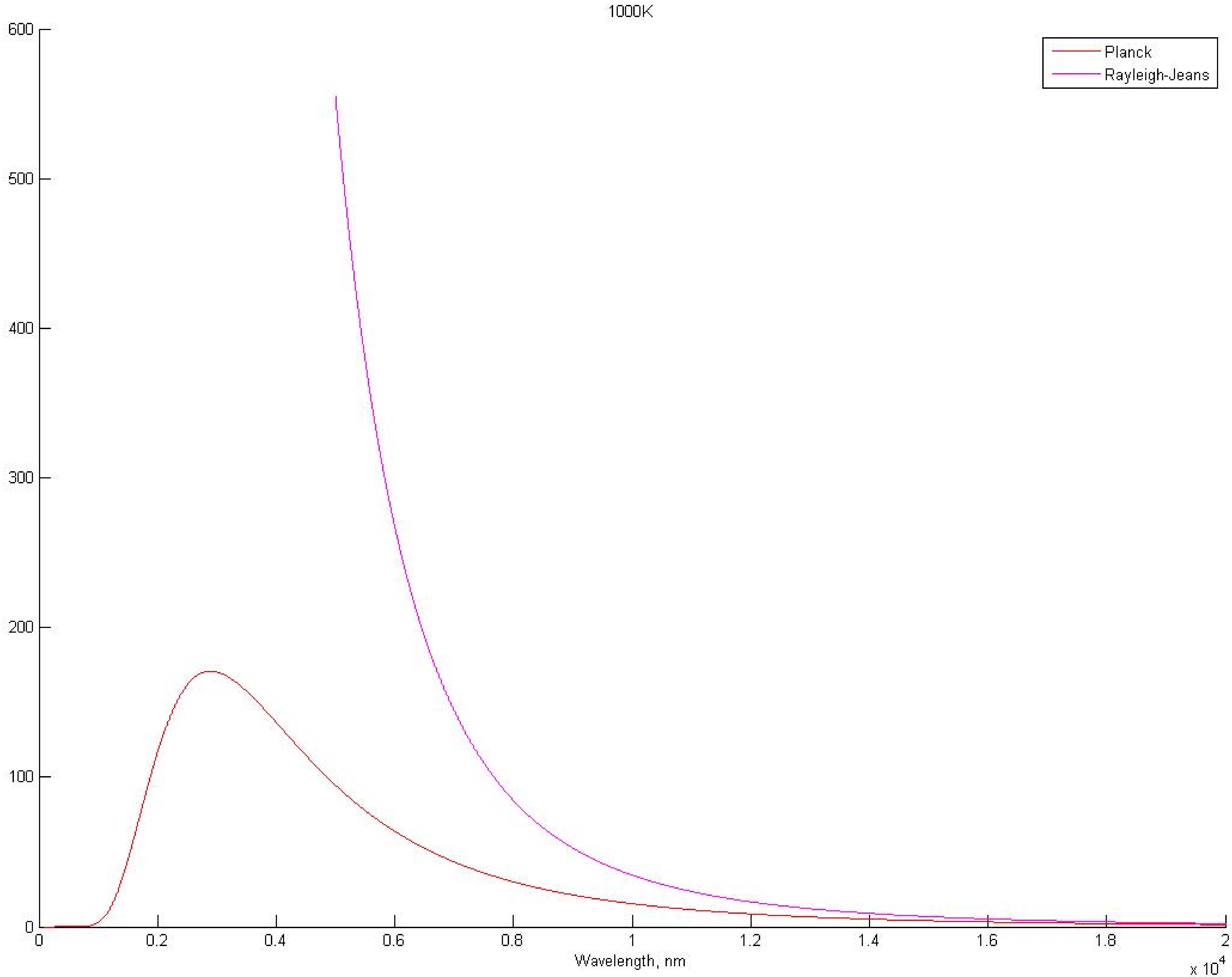
$$u(\omega) = \frac{\omega^2}{\pi^2 c^3} \frac{\hbar\omega}{\hbar\omega/kT} = kT \frac{\omega^2}{\pi^2 c^3}$$

Rayleigh-Jeans-Gesetz

Planck: $$u(\lambda) = \frac{8\pi h c}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

Rayleigh-Jeans: $$u(\lambda) = kT \frac{8\pi}{\lambda^4}$$


195K
Planck
Rayleigh-Jeans
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Wavelength, nm
x 10^4



1000K
Planck
Rayleigh-Jeans
600
500
400
300
200
100
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Wavelength, nm
x 10^4