THE PHOTON POWER AND STEFAN-BOLTZMANN RADIATION LAW

Lecture on the APS March Meeting, Dr. Sergej Reissig, EFBR

In the lecture "About the calculation of the photon power", according to the world-famous formula of Planck and to the model of the photon, which was suggested in the applications [2, 3], the formula for the practical determination of the power of a light particle was derived:

$$P = hf^2 \tag{1}$$

The figure 1 presents the model of the heat transfer, when a photon beam reaches the body. After the collision with the surface, a part of the radiation q_{ref} is reflected, another part is converted into the heat energy. That process we could present, hereby:

$$Q = \varepsilon \cdot P = \varepsilon \cdot hf^2 \tag{2}$$

The useful heat power could be found on the other way that was used in [1]:

$$Q = -\frac{dE_h}{dt} \tag{3}$$

whereby the heat energy E_h could be printed with the equation:

$$E_h = k \cdot T \tag{4}$$

The solution of the eq. (3) together with (4) leads to the expression:

$$-\frac{dE_h}{dt} = -\frac{d(kT)}{dt} = -c \cdot \frac{d(kT)}{d\lambda} \tag{5}$$

If we now will use the well-known Wien displacement law - $\beta = \lambda T = const$ (6)

we could express:

$$Q = -\frac{dE_h}{dt} = -kc\frac{d\left(\frac{\beta}{\lambda}\right)}{d\lambda} = \beta kc\frac{1}{\lambda^2} \tag{7}$$

According to the eq. (2), the heat power can be presented in such form, too:

$$Q = \varepsilon \cdot hf^2 = \varepsilon h\frac{c^2}{\lambda^2} \tag{8}$$

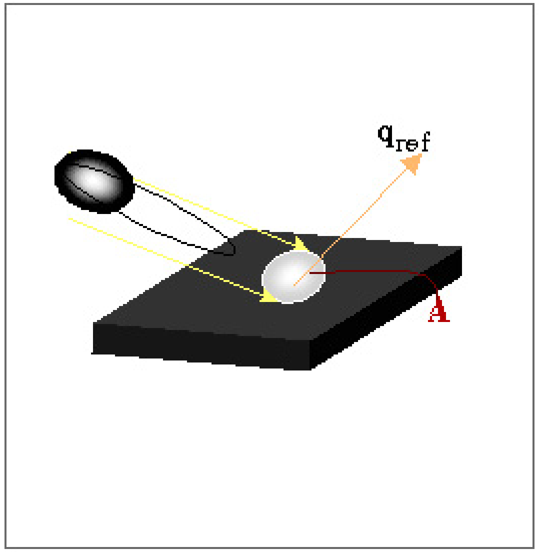

Fig. 1 Heat Radiation Model

As we know, for the calculation of the heat radiation density q we should determinate the effective area of the taken place process - A. From the presented model (Fig. 1) we will proceed on the assumption that the area is depended on the photon size. On the next step the effective radius of the photon should be estimated. The EFBR researches, have shown that the photon radius equals the wavelength, approximately. In this case we can write:

$$r \approx \lambda \qquad A = \pi \lambda^2 \tag{9}$$

The eq. (8) and (9) lead to the formula:

$$q = \frac{Q}{A} = \frac{Q}{\pi \lambda^2} = \varepsilon h \frac{c^2}{\pi \lambda^4} \tag{10}$$

The coefficient ε can be found by the use of the eq. (7) and (8)

$$\varepsilon = \frac{\beta k}{hc} = const \tag{11}$$

With the value of the used constants $\beta = 2.8977686 \times 10^{-3}$, $k = 1.3806503 \times 10^{-23}$, $h = 6.62606876 \times 10^{-34}$, $c = 2.99792458 \times 10^{8}$, we receive: $\varepsilon = 0.201405234$. The use of the Wien displacement law and the expression of the constant ε (11) in eq. (10) led to the formula, finally:

$$q = \frac{\varepsilon h c^2}{\pi \beta^4} T^4 = \frac{kc}{\pi \beta^3} T^4 = const \cdot T^4 = 5.4145630536 \times 10^{-08}\, T^4 \ (\mathrm{W/m^2}) \tag{12}$$

The relative difference between the derived formula (12) and the well-known Stefan - Boltzmann law is less than 5% (4,51%).

Conclusion:

- *The good agreement between the derived formula and the well-known Stefan - Boltzmann law let us conclude that the formula for the calculation of the photon power as well as the presented heat radiation model are correct.*
- *The radiation model could be used in the future theoretical and experimental research as well as engineering calculations*
- *The photon radius has been determined.*

References

1. About the calculation of the photon power. S. Reissig, Lecture on the APS March meeting, Montreal, 2004
2. About the dualism of the light. S. Reissig, The 12th General Conference of the European Physical Society "Trends in Physics", Budapest, 2002
3. About the nature of the photon. S. Reissig, www.efbr.de/de/publikationen/EFBR%20Publikationen.htm, 2003