NASLOV
ZAKLJUČAK / REZULTAT
VIDI VIŠE
OBRATI PAŽNJU

ZAKONI ZRAČENJA I (SPEKTRO)FOTOMETRIJSKE VELIČINE

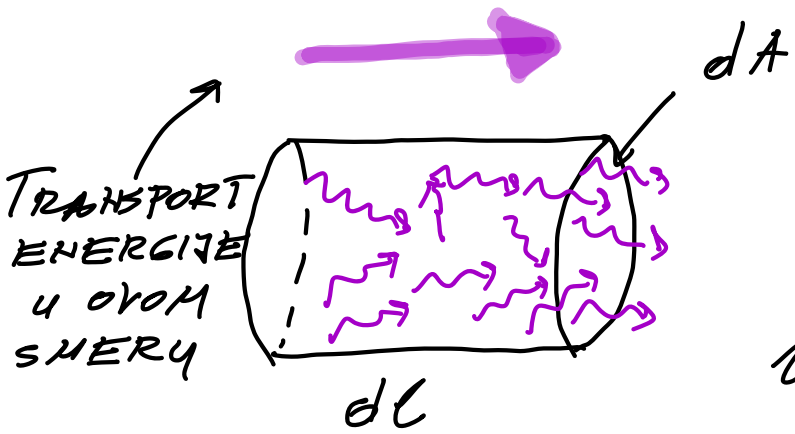
PITANJA NA KOJA SU FIZIČARI HTELI DA ODGOVORE KRAJEM XIX I POČETKOM XX VEKA:

* KAKO EM TALASI NASTAJU I NESTAJU
* KAKO TELA EMITUJU I APSORBUJU?
* KAKVA JE PRIRODA EM TALASA / SVETLOSTI

KIRCHHOFF-OVI ZAKONI EMISIJE I APSORPCIJE, POSTULIRANJE CT

* SETITE SE PREDAVANJA (SPEKTRI, LINIJE, ETC)
* SETITE SE KONTINUALNOG, ABS. I EMISIONOG SPEKTRA.

VELIČINE (KIRCHHOFF JE VEĆ ZNAO ZA OVU FORMULACIJU)



dE ← UKUPNA ENERGIJA SVIH FOTONA.

$u = \frac{dE}{dV}$ ← GUSTINA ENERGIJE

$$P^{EM} = \frac{dE^{EM}}{dt}$$ ← EMITOVANA (IZLAZNA SNAGA)

(NPR. LUMINOZNOST)

$$F^{EM} = \frac{dE^{EM}}{dA\,dt}$$ ← EMITOVANI (IZLAZNI) FLUKS

MOŽEMO DA DEFINIŠEMO I UKUPAN FLUX:

$$F = \frac{dE}{dA\,dt}$$ (NEKAD SE ZOVE I GUSTINA FLUKSA)

OČIGLEDNO: $P = \oint_A F\,dA$ ← OVDE SMO IMPLICITNO DEFINISALI DA JE $F \parallel dA$

GENERALNIJE: $$P = \oint_A \vec{F} \cdot d\vec{A}$$

SVE OVE VELIČINE MOŽEMO DEFINISATI I SPEKTRALNO (PO TALASNOJ DUŽINI):

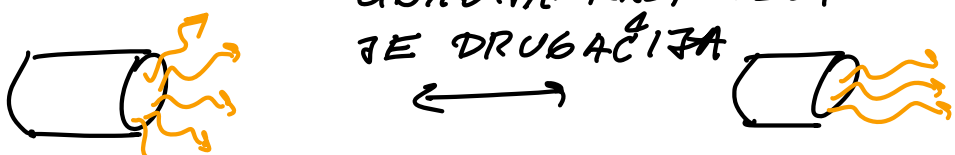
$$P_\lambda = \frac{dP}{d\lambda} \quad \left(P_\nu = \frac{dP}{d\nu}\right)$$

$$F_\lambda = \frac{dF}{d\lambda} \quad \left(F_\nu = \frac{dF}{d\nu}\right)$$

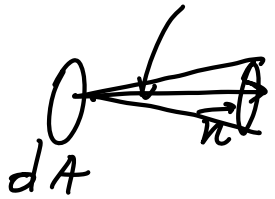
} 5 MIN O SMISLU I JEDINICAMA

SPECIFIČNI MONOHROMATSKI INTENZITET

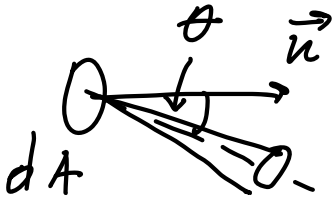
UGAONA RASPODELA JE DRUGAČIJA $\longleftrightarrow$



$d\Omega = \sin\theta \, d\theta \, d\varphi$

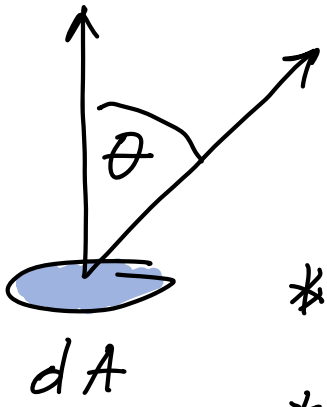


$$I_\lambda = \frac{dF_\lambda}{d\Omega},$$ TAČNIJE:



$$I_\lambda = \frac{dF_\lambda}{d\Omega \cos\theta}$$

DALJE:



$$I_\lambda = \frac{dE}{dt\,dA\,d\lambda\,d\Omega\cos\theta}$$

* JEDINICE ?
* DIMENZIJE ?
* VEKTOR ILI SKALAR ?

} 7-8 MIN

PRIMERI:

(NET)

① AKO JE I_λ IZOTROPNO. NAĐI: a) UKUPAN FLUKS

b) IZLAZNI FLUKS:

a) $I_\lambda = \frac{dF_\lambda}{d\Omega\cos\theta} \Rightarrow F_\lambda = \int_0^{2\pi}\int_0^{\pi} I_\lambda \cdot d\Omega\cos\theta\sin\theta\,d\theta d\varphi$

$= \emptyset$ (ASOCIRAJMO NA CRNO TELO)

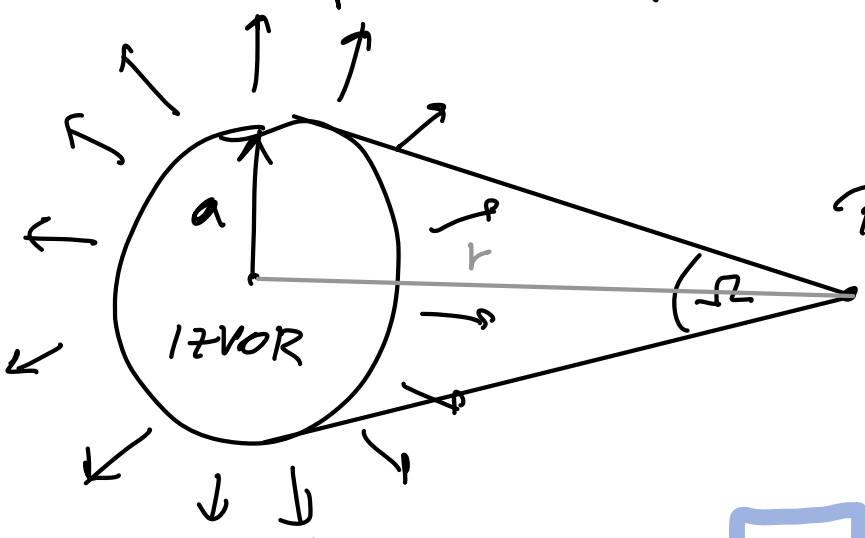
b) $F_\lambda^{EM} = \int_0^{2\pi}\int_0^{\pi/2} = I_\lambda \int_0^{2\pi}\int_0^{\frac{\pi}{2}} \cos\theta\sin\theta\,d\theta d\varphi =$

$= 2\pi\int_0^{\frac{\pi}{2}} \frac{1}{2}\cos\underbrace{2\theta}_{u}\,d\theta =$

$I_\lambda \searrow = 2\pi\cdot\frac{1}{4}\int_0^{\pi}\sin u\,du = I_\lambda\frac{\pi}{2}\cdot 2 = \pi\cdot I_\lambda$

INTENZITET U POTPUNOSTI (DO NA POLARIZACIJU)

OPISUJE POLJE ZRAČENJA.



(PRIMLJENI) INTENZITET: $I_\lambda \approx \frac{F_\lambda}{\Omega} = \frac{\mathcal{L}_\lambda / 4\pi r^2}{\pi a^2 / r^2} =$

$= \frac{\mathcal{L}_\lambda}{4\pi a^2 \pi} = \frac{F_\lambda^+}{\pi} \approx I_\lambda^+$ NE ZAVISI OD UDALJENOSTI

(AKO JE IZOTROPNO

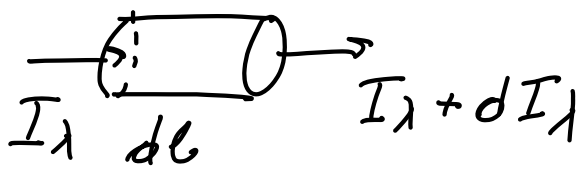
POVRŠINSKI SJAJ (U STVARI EMITOVANI FLUKS)

EMITOVANI INTENZITET JE JEDNAK PRIMLJENOM (VIDETI "TEOREMA RECIPROCITETA")

KIRCHHOFF I POSTULACIJA ACT:

EMISIJA: DOPRINOS INTENZITETU

$$\mathcal{J}_\lambda = \frac{dI_\lambda}{d\ell}$$



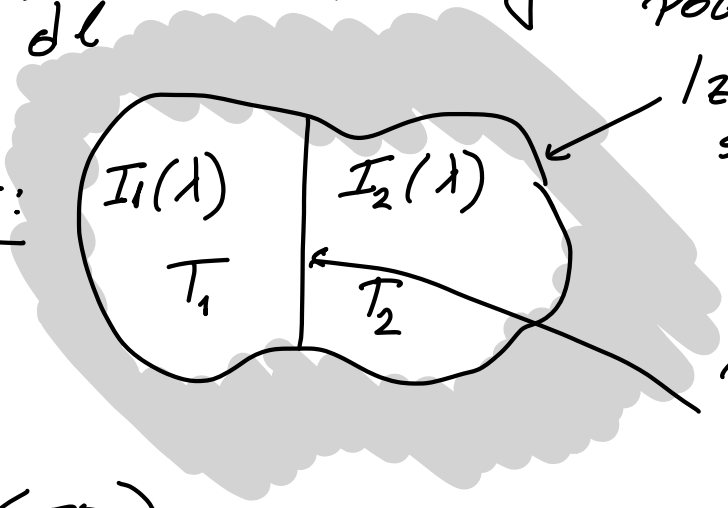
APSORPCIJA: DEFICIT INTENZITETA

$$dI_\lambda = -\chi_\lambda \cdot I_\lambda \, d\ell$$

KOEFICIJENTI APSORPCIJE /EMISIJE.

UKUPNO: $\frac{dI_\lambda}{dl} = -\chi_\lambda I + j_\lambda$ (REŠAVAĆEMO POLA SEMESTRA)

KIRCHHOFF:



$T_1 = T_2$ (TR)

AKO JE $I_1(\lambda) \neq I_2(\lambda)$ ONDA BI ENERGIJA BILA TRANSPORTOVANA

ALI $T_1 = T_2 \Rightarrow$ NEMA GREJANJA / HLAĐENJA

$I_{\lambda,1} = I_{\lambda,2} = B_\lambda(T)$ ← APSOLUTNO CRNO TELO

TAKOĐE

$\frac{dI_\lambda}{dl} = -\chi_\lambda \cdot I_\lambda + j_\lambda = 0$ ZA A.C.T.

PA JE $\frac{j_\lambda}{\chi_\lambda} = B_\lambda(T)$ → ZA BILO KOJU PRIRODU APSORPCIJE I EMISIJE

KIRCHHOFF: „IT IS OF UTMOST IMPORTANCE TO FIND THIS FUNCTION"

ŠTEFAN-BOLTZMANN:

ŠTEFAN IZMERIO: $-\frac{dE}{dt} \propto T^4$

(NA NAŠEM JEZIKU $\mathcal{E} \propto T^4$ ← EMISIVNOST)

DOKAZ: POSMATRAJMO GAS ČESTICA (HELLO? PHOTONS?)

1-VI ZAKON TD: $\delta Q = dU + pdV \;/\; \frac{\partial}{\partial V}$

ENTROPIJA: $dS = \frac{\delta Q}{T}$

$TdS = dU + pdV$

$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V$ (MAKSVEL. REMACIJA)

$T\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial U}{\partial V}\right)_T + p$

$T\left(\frac{\partial p}{\partial T}\right)_V = \left(\frac{\partial U}{\partial V}\right)_T + p$

$\boxed{p = \frac{1}{3}u}$ DOMAĆI ĆE BITI

$U = u \cdot V$

$\frac{1}{3} T\left(\frac{\partial u}{\partial T}\right)_V = u + \frac{u}{3} = \frac{4u}{3} \Rightarrow \frac{\partial u}{u} = 4\frac{\partial T}{T}$

$u = a \cdot T^4 \Longrightarrow \mathcal{E} = \sigma T^4$

ZAŠTO? OBJASNIMO, ILI DOMAĆI :-)

WIENOV ZAKON POMERANJA:

1893: OPET TD : REVERZIBILNA, ADIJABATSKA EKSPANZIJA "GASA ZRAČENJA"

$$\delta Q = dU + p dV$$

$$U = uV, \quad p = \frac{1}{3}u$$

$$d(uV) + \frac{1}{3} u dV \Rightarrow u dV + V du + \frac{1}{3} u dV = 0$$

$$\frac{du}{u} = -\frac{4}{3}\frac{dV}{V}$$

$$u = \text{const.}\ V^{-\frac{4}{3}}$$

$$T^4 \propto V^{-\frac{4}{3}} \Rightarrow T \propto V^{-\frac{1}{3}}$$

$$T \propto \frac{1}{R} \quad (R \propto \lambda_{max})$$

$$\boxed{\lambda_{MAX} \propto \frac{1}{T}}$$

WIENOV ZAKON

KONAČNO, PLANK:

$$I_\lambda = \frac{2hc^2}{\lambda^5} \cdot \frac{1}{e^{\frac{hc}{\lambda kT}} - 1} \quad ; \quad \varepsilon_\lambda = \pi I_\lambda$$

$$u_\lambda = \frac{1}{c} 4\pi I_\lambda \quad , \text{ ET.C.}$$

ZADATAK 2: AKO SUNCE ZRAČI KAO ACT (NE ZRAČI), IZRAČUNAJ BROJ FOTONA KOJI PADNU NA TELESKOP POVRŠINE $1\,m$, U JEDNOJ SEKUNDI, NA $\lambda = 500\,nm$, U INTERVALU $\Delta\lambda = 1\,pm$.

PROVEŽBAJTE, PRODISKUTUJTE I_λ, F_λ ... ETC.

AKO BUDE VREMENA: $I_\lambda \rightarrow I_\nu$.