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Description of Ionizing Radiation Fields

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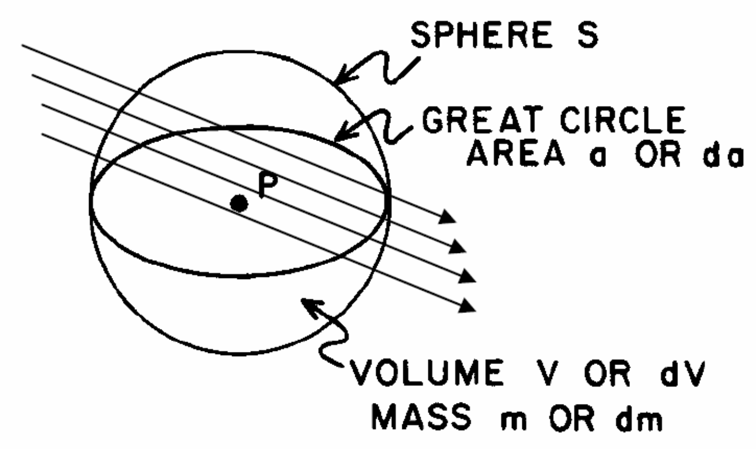
Description of Radiation Fields

- Radiation field: field of ionizing particles, where the particles can have a direction and energy distribution
- Radiation field against a (infinitesimal) sphere:



- Number of particles N which hit the sphere will give a relative value of the absorbed dose
- By using interaction theory the absolute value can be determent

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Fluence, Φ 1)

- Fluence Φ: number *dN* particles which hit the sphere per area unit *da* (during a period of time)

$$\Phi = \frac{dN}{da} \qquad (da \text{ the greates area of the sphere})$$

- The infinitesimal sphere defines a point in space
- Fluence is an expectation value; N is a stochastic variable
- In a field of radiation, which for instance traverse a substance, the fluence will diversify from point to point due to the absorption and scattering $\rightarrow \Phi = \Phi(\vec{r})$

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Fluence, Φ 2)

- Fluence can have a time variation – fluence *rate*:

$$\varphi = \frac{d\Phi}{dt} = \frac{d^2N}{dtda}$$

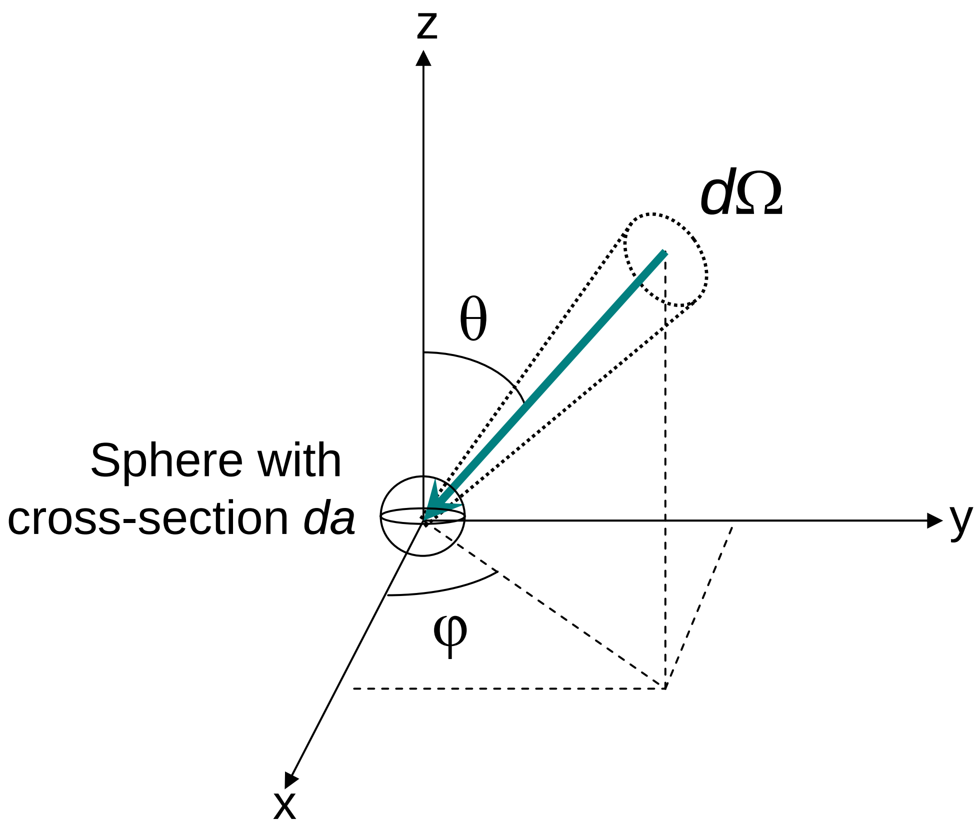
- The radiation field can have particles with a direction and energy distribution. Differential fluence:

$$\Phi_T = \frac{d\Phi}{dT} \qquad \Phi_\Omega = \frac{d\Phi}{d\Omega} \quad (d\Omega = \sin\theta d\theta d\varphi)$$

- Φ_T the number of particles per energy and area in the energy interval [T, T+dT] which hit the sphere

Definition of direction

- The differential fluence per unit angle Φ_Ω is the number of particles per element of solid angle and area in the solid angel interval [Ω, Ω +dΩ] which hit the sphere



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Energy fluence, Ψ

- What amount of energy from the radiation field hits the sphere?
- Energy fluence: $\Psi = \int_0^{T_{max}} T\Phi_T dT$
- With a monoenergetic field: $\Psi = T\Phi_T = T\frac{dN}{da}$
- Differential units:

$$\Psi_T = \frac{d\Psi}{dT} = T\Phi_T, \quad \Psi_\Omega = \frac{d\Psi}{d\Omega} = \int_0^{T_{max}} T\frac{d\Phi_T}{d\Omega}dT$$

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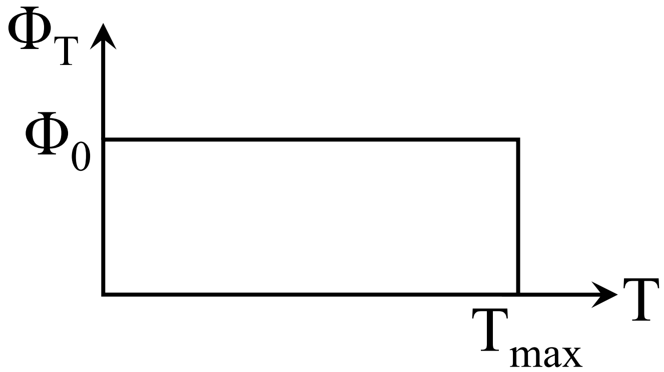
Fluence vs. Energy Fluence 1)

- If the differential fluence per energy unit is constant in the energy interval $T=[0\,,\,T_{max}]$:

$$\Phi_T = \Phi_0 \;\Rightarrow\; \Phi = \int_0^{T_{max}} \Phi_T \, dT$$

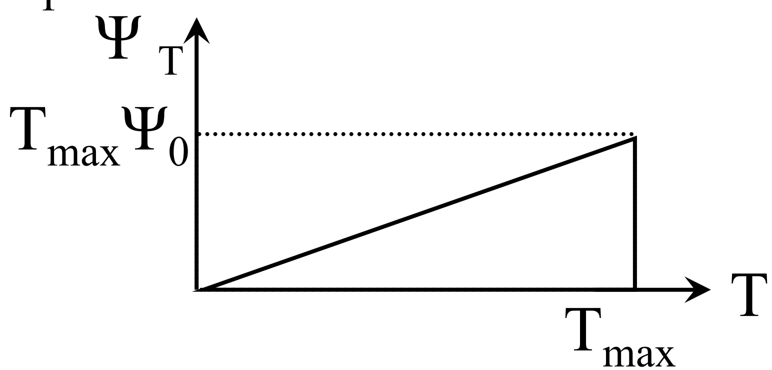
$$\Rightarrow \underline{\underline{\Phi = T_{max}\Phi_0}}$$



- Then the (differential) energy fluence gets:

$$\Psi_T = T\Phi_T \;\Rightarrow\; \Psi = \int_0^{T_{max}} \Psi_T \, dT = \int_0^{T_{max}} T\Phi_T \, dT$$

$$\Rightarrow \underline{\underline{\Psi = \frac{1}{2} T_{max}^2 \Phi_0}}$$



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Fluence vs. Energy Fluence 2)

- The X-ray spectrum is ether ~ differensiell fluence or differencial energy fluence. Problem: often given as “intensity”
- In this example is:

  $\langle T \rangle_{\Phi} \approx 60.7$ keV

  $\langle T \rangle_{\Psi} \approx 64.8$ keV
- Always ask what the y-axis in a spectrum denotes!