

Workshop “Nuclear, Particle physics and Cosmology”
16-18 May 2017, Oslo

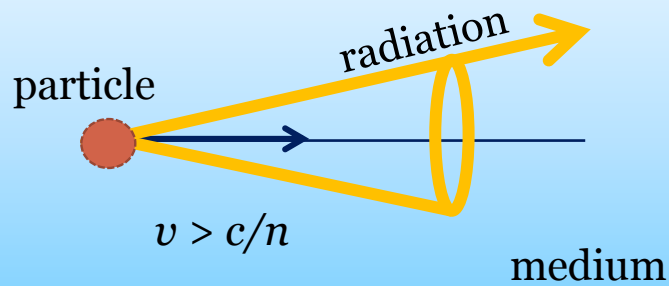


A new source of Smith-Purcell radiation from the structure controlled by the laser field

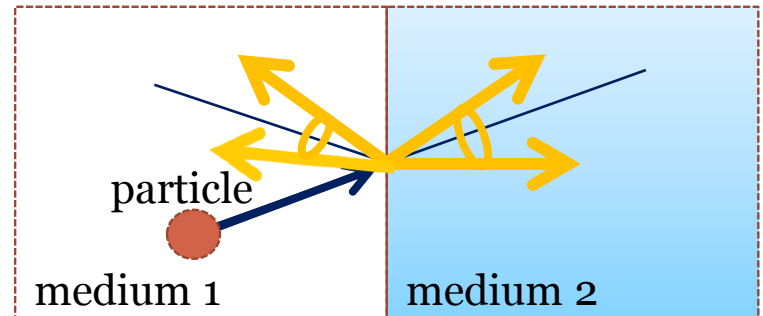
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Polarization Radiation

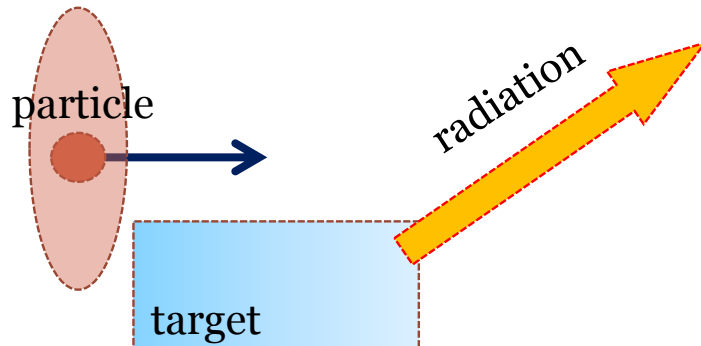
Cherenkov Radiation



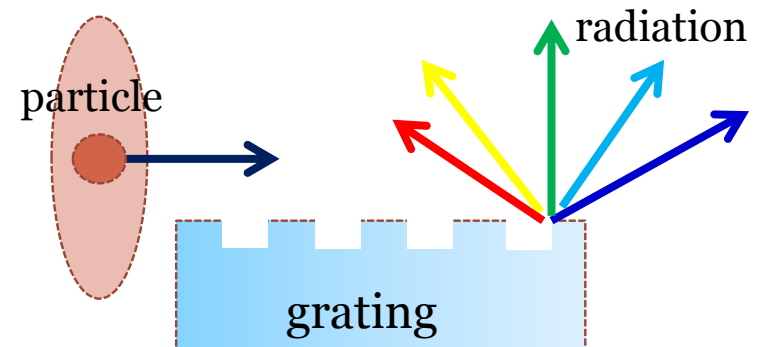
Transition Radiation



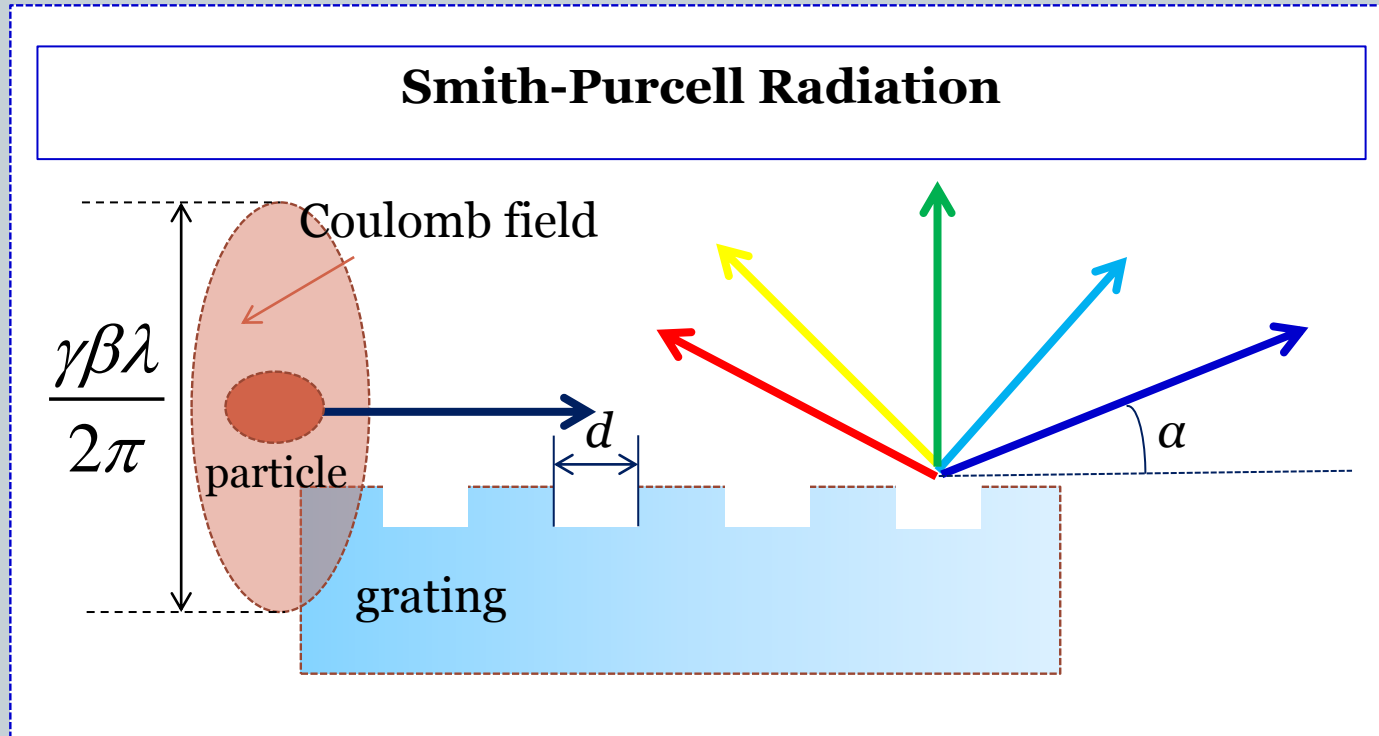
Diffraction Radiation



Smith-Purcell Radiation



Smith-Purcell Radiation



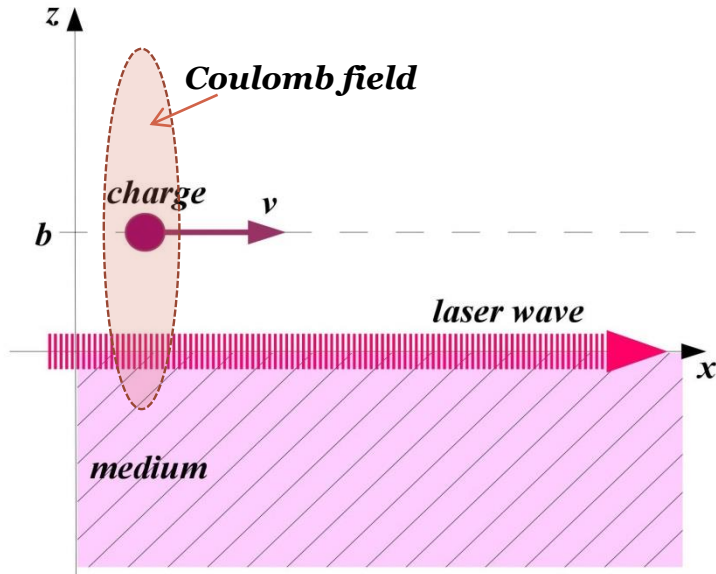
$$\lambda_n = \frac{d}{n} \left(\beta^{-1} - \cos \alpha_n \right), \quad \beta = \frac{v}{c}, \quad n = 1, 2, \dots$$

SPR Applications



- A good source of electromagnetic radiation (microwave, terahertz and optical region)
- Noninvasive beam diagnostics
- Free Electron Laser

Geometry of the SPR source



Particle Coulomb field

$$\mathbf{E}^P(\mathbf{r}, t) = \int d^3q \int d\omega \mathbf{E}^P(\mathbf{q}, \omega) e^{i\mathbf{q}\mathbf{r} - i\mathbf{q}\mathbf{v}t}$$

$$\mathbf{E}^P(\mathbf{q}, \omega) = -\frac{ie}{2\pi^2} \frac{\mathbf{v}(\mathbf{q}\mathbf{v})/c^2 - \mathbf{q}}{q^2 - (\mathbf{q}\mathbf{v})^2/c^2} e^{iq_z b} \delta(\omega - q_x v)$$

Laser field

$$\mathbf{E}^w(\mathbf{r}, \omega) = \mathbf{E}^w \left\{ e^{i\mathbf{k}_0\mathbf{r}} \delta(\omega - \omega_0) + e^{-i\mathbf{k}_0\mathbf{r}} \delta(\omega + \omega_0) \right\}$$

Nonlinear polarization of the medium

$$\mathbf{D}(\mathbf{r}, \omega) = \varepsilon(\omega) \mathbf{E}(\mathbf{r}, \omega) + 4\pi \mathbf{P}^{NL}(\mathbf{r}, \omega)$$



$$P^{NL} \sim (E^w)^2 E^P$$

$$\varepsilon(\omega) \rightarrow \varepsilon(\mathbf{r}, \omega)$$

Characteristics of SPR

Spectral and angular distribution of the SPR energy

$$\frac{d^2W^\mp(\mathbf{n})}{d\Omega d(h\omega)} = \frac{4\pi}{137} \gamma^2 a^2 \chi^2(\omega) T(E_z^w)^4 \frac{\omega^6 \cos\theta \sin^2\theta \sin^2\varphi \delta(\omega - (\mathbf{q}_r \mp 2\mathbf{k}_0) \cdot \mathbf{v} \mp 2\omega_0)}{c^4 \left(\frac{\omega}{c} \sin\theta \cos\varphi \mp 2k_{0x} \right)^2 + \gamma^2 \frac{\omega^2}{c^2} \sin^2\theta \sin^2\varphi} \times$$

$$\times \left[\frac{\varepsilon(\omega) - \sin^2\theta}{\left(\sqrt{\varepsilon(\omega) - \sin^2\theta} + \varepsilon(\omega) \cos\theta \right)^2} \sin^2\varphi + \frac{1}{\left(\sqrt{\varepsilon(\omega) - \sin^2\theta} + \cos\theta \right)^2} \cos^2\varphi \right] \times$$

$$\times \exp \left\{ -\frac{2b}{\gamma} \sqrt{\left(\frac{\omega}{c} \sin\theta \cos\varphi \mp 2k_{0x} \right)^2 + \gamma^2 \frac{\omega^2}{c^2} \sin^2\theta \sin^2\varphi} \right\}$$

Parameter adjustment

For small γ :

$$\frac{2b\omega}{\gamma c} < 1$$

For large γ :

$$\frac{2b\omega}{c} < 1$$

Dispersion relation

$$\omega = 2 \frac{\mathbf{k}_0 \cdot \mathbf{v} - \omega_0}{1 - \frac{v}{c} \sin\theta \cos\varphi}$$

Dispersion relation for SPR

Dispersion relation

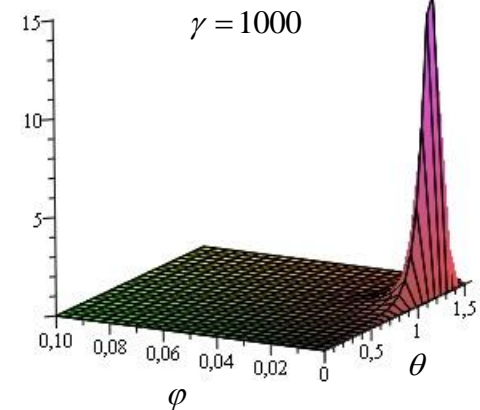
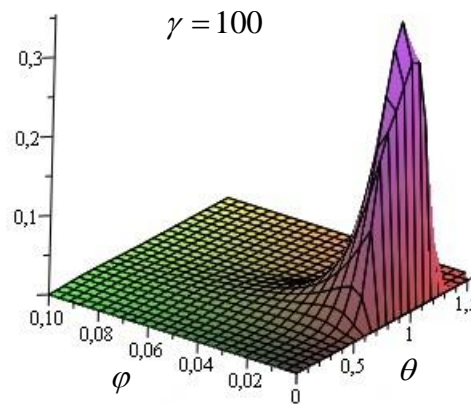
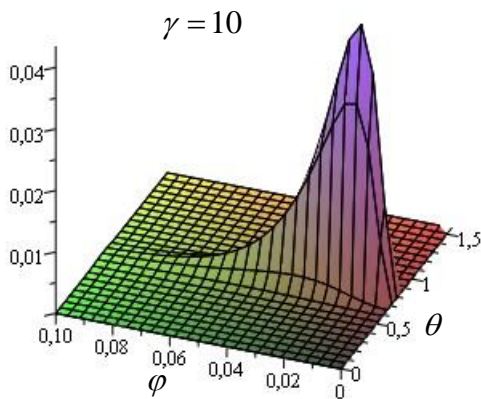
$$\omega = 2\omega_0 \frac{\beta \sqrt{\varepsilon(\omega_0)} - 1}{1 - \beta \sin \theta \cos \varphi}$$

Polar angle

Azimuthal angle

SPR with the tunable frequency

No diffraction orders!





**Thank you
for your
attention!**