

NON-DIPOLARITY OF AXIAL CHANNELING RADIATION AT GEV BEAM ENERGIES

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OUTLINE

- Introduction
- Axial channeling radiation (classical) dipole approximation
- Non-dipole approximation for axial channeling
- Comparison of non-dipole with dipole approximation
- Summary

Planar channeling: one-dimensional problem

Axial channeling: two-dimensional problem

A. Savchenko, Channeling 2018, Ischia, Italy

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For planar channeling in dipole approximation total radiated energy in thin crystal:

$$\frac{d^2 E}{d\hbar\omega d\Omega} = \frac{e^2}{4\pi^2 \hbar c} \int_0^\tau e^{i(\omega t - \vec{k} \cdot \vec{r})} \frac{\vec{n} \times ((\vec{n} - \vec{\beta}) \times \vec{\beta})}{(1 - \vec{\beta} \cdot \vec{n})^2} dt$$

$$\frac{dE}{d\hbar\omega\Delta z} = \frac{e^2\omega}{\hbar c^4 T^2} \sum_{n=1}^{\infty} \Theta\left[1 - \eta_n\right] (\eta_n^2 - \eta_n + \frac{1}{2}) \cdot \left|\dot{x}_{\tilde{\omega}}\right|^2$$

$$\eta_n = \frac{T\omega}{4\pi\gamma^2 n}; \quad \tilde{\omega} = \frac{2\pi n}{T}; \quad \dot{x}_{\tilde{\omega}} = \int_0^T \dot{x} e^{i\tilde{\omega}t} dt$$

B.Azadegan, W.Wagner, Simulation of planar channeling-radiation spectra of relativistic electrons and positrons channeled in a diamond-structure or tungsten single crystal (classical approach), NIMB **342**, 144 (2015)

A. Savchenko, Channeling 2018, Ischia, Italy

Example of transverse trajectory together with energy spectra for one incidence point of a 2 GeV electron into a W single crystal with respect to the (110) plane

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For planar channeling in non-dipole approximation:

At relativistic energies the longitudinal velocity component is coupled with the transverse component through

$$\gamma = \frac{1}{\sqrt{1 - \frac{(V_x^2 + V_z^2)}{c^2}}}$$



Comparison of CR spectra obtained in dipole approximation (dotted curve) and non-dipole approximation (full curve) for a 2 GeV electron channeled in the (110) plane of a W single crystal.

B.Azadegan, W.Wagner, Non-dipolarity of channeling radiation at GeV beam energies, NIMB **402**, 63 (2017)

A. Savchenko, Channeling 2018, Ischia, Italy

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plarity of channeling radiation at GeV beam energies, NIMB **402**, 63 (2017)

A. Savchenko, Channeling 2018, Ischia, Italy

York, 1996).



Positrons in Si (110) with parabolic potential U = 20 eV 1 - 6 GeV 2 - 14 GeV 3 - dipole case son of CR spectra obtained in dipole nation (dotted curve) and non-dipole ation (full curve) for a 2 GeV channeled in the (110) plane of a W stal.

100

Photon energy (MeV)

50

n at GeV beam energies, NIMB **402**, 63 (2017)

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150

200



Comparison of CR energy spectra obtained in dipole approximation (dotted curves) and non-dipole approximation (full curves) for electrons of energy of 0.2 GeV (left panel) and 5 GeV (right panel) channeled in the (110) plane of a W single crystal.

This effect can not be neglected at beam energies larger than about 1 GeV.

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AXIAL CHANNELING IN DIPOLE APPROXIMATION

W single crystal axis potential<100>



A. I. Akhiezer, N. F. Shulga, High-Energy Electrodynamics in Matter (Gordon and Breach, New York, 1996).

A. Savchenko, Channeling 2018, Ischia, Italy

Electron trajectories for different incidence points of electrons of energy 3 GeV into a 20 μ m thick W single crystal at zero angle of incidence with respect to the <100> axis.

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AXIAL CHANNELING IN NON -DIPOLE APPROXIMATION

Like it was for planar case: At relativistic energies the longitudinal velocity component is coupled with transverse components through

$$\frac{d\vec{p}}{dt} = \frac{d}{dt} \left(\frac{m\vec{v}}{\sqrt{1 - \left(v_x^2 + v_y^2 + v_z^2\right)/c^2}} \right) = \vec{F}\vec{F}$$

$$\gamma = \frac{1}{\sqrt{1 - \frac{(V_x^2 + V_y^2 + V_z^2)}{c^2}}}$$

 $\frac{ap_z}{dt} = 0$

3D problem! It take a lot of computational time.

COMPARISON OF NON-DIPOLE MITH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for an electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

A. Savchenko, Channeling 2018, Ischia, Italy

COMPARISON OF NON-DIPOLE MATH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for an electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

A. Savchenko, Channeling 2018, Ischia, Italy

25.09.2018

COMPARISON OF NON-DIPOLE WITH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for an electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

A. Savchenko, Channeling 2018, Ischia, Italy

25.09.2018

COMPARISON OF NON-DIPOLE MITH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for an electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

A. Savchenko, Channeling 2018, Ischia, Italy

25.09.2018

COMPARISON OF NON-DIPOLE WHT DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for an electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

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25.09.2018



A. Savchenko, Channeling 2018, Ischia, Italy

POSITRON SOURCE 17



Crystalline radiator Amorphous convertor

For more information:

B.Azadegan, A.Mahdipour, S.B.Dabagov, W.Wagner, distributions from a hybrid positron source based on hanneling radiation, NIMB **309**, 56 (2013)

A. Savchenko, Channeling 2018, Ischia, Italy

SUMMARY

- We treated planar as well as axial channeling radiation at different energies and developed several software codes (Mathematica) appropriate for classical calculations.
- We investigated the influence of non-dipolarity on channeling radiation. This effect can not be neglected at beam energies larger than about 1 GeV at planar channeling and lager then about 500 MeV at axial channeling.
- This effect is also important for the simulation of positron production by means of channeling radiation.



THANK YOU FOR YOUR ATTENTION!!!

A. Savchenko, Channeling 2018, Ischia, Italy

BACKUP

COMPARISON OF NON-DIPOLE WITH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for a 200 and 500 MeV electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

COMPARISON OF NON-DIPOLE WITH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for a 800 MeV and 2 GeV electron channeled along {1,0,0} axis of a 20 um W single crystal for 0.1 mrad incidence angle.

COMPARISON OF NON-DIPOLE WITH DIPOLE APPROXIMATION



Comparison of CR spectra obtained in dipole approximation (green curve) and non-dipole approximation (magenta curve) for a 5 GeV electron channeled along $\{1,0,0\}$ axis of a 20 um W single crystal for 0.1 mrad incidence angle.

A. Savchenko, Channeling 2018, Ischia, Italy