To those who have your own PC:

Please access the URL below, download and install SPECTRA before the lecture starts. If you have any problem, please let me know.

21255

http://radiant.harima.riken.go.jp/spectra/index.html

SPECTRA- a synchrotron radiation calculation code

Welcome to the SPECTRA home page! Getting Started 2012/01/27: Version 9.0.2 has been released Screen Shots Version History at is SPECTRA? SIMPLEX Home SPEC is an application software to calculate optical properties of synchrtron radiation emitted from bending magnets, wigglers (conventional and elliptical) and undulators (conventional, helical, elliptical and figure-8). SPring-8 Home Calculations of radiation from an arbitrary magnetic field distribution is also available. Parameters on the electron beam and the source can be editted completely on graphica user interfaces (GUIs) and it is possible to show the calculation result graphically. The energy spectrum and radiation power after transmitting various filters and convolution of detector's resolution are also available. Supported Operating Systems The graphical part of SPECTRA is writtend in the C++ language with wxWidgets GUI tool kit and OpenGL graphic library. Thanks to portability of these libraries. SPECTRA will run on most available operating systems such as Microsoft Windows, Mac OS X, Linux, and most unix-like operating systems.

Important Notes on Brilliance Calculation

Home

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From version 7.0, the definitions of the natural divergence and source size of undulator radiation, which are necessary to calculate the brilliance, have been change as summarized in the below table. Because of this, the brilliance of undulator radiation calculated with 7.0 or later may be lower than that with 6.1 or earlier by about factor of 0.3 to 0.4 (dependent on the undulator and accelerator parameters)

	Version 6.1 or earlier	Ver7.0 or later
Natural divergence	$\sigma_{r'} = \sqrt{\frac{\lambda}{L}}$	$\sigma_{r'} = \sqrt{\frac{\lambda}{2L}}$
Natural size	$\sigma_r = \frac{\sqrt{L\lambda}}{4\pi}$	$\sigma_r = \frac{\sqrt{2L\lambda}}{4\pi}$

In addition, the brilliance of wiggler radiation is calculated with the depth of the field taken into account, from version 7.1. This may result in a lower value of the brilliance calculated with the version 7.1 or later, e.g., 1 or 2 orders of magnitude, than that with the earlier versions.



Introduction to SPECTRA

Takashi TANAKA RIKEN SPring-8 Center

What is SPECTRA?

- Quantitative evaluation of SR is necessary to design optical elements in the beamline, analyze the experimental data, etc.
- This requires not only expertise on SR but also numerical implementation to take into account the e-beam effects.
- SPECTRA is computer software to help the SR users to accurately evaluate the optical characteristics of SR from various sources.

Functions Supported

- Spectrum of photon flux (density)
- Spatial profile of photon flux and radiation power
- K-value dependence of photon flux and radiation power
- Degree of polarization (Stokes parameters)
- Brilliance curve
- Filtering
- Coherent radiation
- Fully graphical pre- and post-processor
- • • • •

General Instruction (1)

- 1. After starting the program, open a parameter file or run [File]-[Create New].
- 2. GUI panels pop up to show the parameters defining the accelerator and light source.
- 3. Edit the parameters related to the accelerator and light source.
- 4. Save the parameter file if necessary.

SPECTRA 9.0 - C	¥TT¥wx¥spectra9.0¥pr	m¥spring8.prm	
<u>File</u> <u>Select</u> Calculation	<u>R</u> un Open <u>U</u> tility <u>C</u> onfig	uration <u>H</u> elp	
-Accelerator Specificati	on		
Storage Ring			
Bunch Profile: Gauss	sian 🔽	Energy Spread 0.001	
Electron Energy (Ge∖	ŋ 8	β _X (m) 22.58 c	χ _χ Ο
Average Current (mA)	100	β _y (m) 5.61 c	_{έγ} Ο
Circumference		η _x (m) 0.11 r	lx' 0
Bunches			ly' 0
	5.99585	1/γ(μrad) 63.8749	(h 40.00
Peak Current (A)	3.92212	- σ _X (μm) 297.9 c	5χ(μrad) 12.26 5χ(urad) 1.100
Natural Emittance (m	.rad) 3.4e-09	νσ ₂ ν 0.1919 γ	γγμμασ) 1.100 (σ _v) 0.01722
Coupling Constant	0.002	1	-,
ε _x (m.rad) 3.393e-009	9 ε _γ (m.rad) 6.786e-012		
Links Down a Doctoriat			
Light Source Descripti	on		
Linear Undulator Ga	p-Field Table		
Segmented Undula	itor	σ _r (μm) 3.55916 c	s _r (μrad) 4.99171
🔲 Special Magnet Se	etup	$\Sigma_{\rm X}(\mu m) = 297.878 = 2$ $\Sigma_{\rm V}(\mu m) = 7.12316 = 5$	_{2χ} (μrad) 13.236 ω(urad) 5.11144
Gap Value	9.15509	ε1st(peak:eV) 5544.0	λγ(μιασ) 3.11144 J2
B(T)	0.736295 in ht	 Gard(peak;eV) 16647 	.8
Periodic Length (cm)	3.2	710×1 st 8.9546	63e+014
Total Length (m)	4.5	Brilliance _{1 st} 1.5800	J7e+020
Number of Periods	140	Bose Degeneracy 0.028	7544
K Value	2.2	Total Power (kW) 9.834	53
ε _{1st} (e∨)	5553.42		

General Instruction (2)

- 5. Select the type of calculation (dependency and main item) from submenus of [Select Calculation].
- 6. Edit the parameters related to calculation controls.

🗖 Energy Dependence – Partial Flux			
Observation			
Observation Point in Angle		Numerical Conditions	
Distance from the Source (m)	30	Zero Emittance	
Initial Energy (eV)	5000		
Final Energy (e∨)	100000		
Energy Pitch (eV)	2	Output File Settings	
x _{slit} (mm)	Q	Print Header	
y _{slit(mm)} Calcula	tion	Controls	
ε _{1st} @x,yslit(eV)	5553.42		
∆x (mm)	2	Flux (photons/sec/0.1%B.W.)	
∆y (mm)	1	PL(s1/s0) PC(c3/c0)	
Easy Calc. > 200000	e∨	PL45(s2/s0)	
🗹 Auto Pitch: Rel. Difference	0.5	1- PL	
EFiltering Generic Filter	~		
Convolution		·	

General Instruction (3)

- 7. After specifying all the parameters and selecting options, run [Run]-[Start Calculation] command to start a calculation.
- 8. Input a file name to save the calculation results in the dialog box.
- 9. A progress bar pops up to indicate the status of the calculation.

SPECTRA 9.0 - C:4	≮TT¥wx¥spectra9.0¥pr Run Open Utility Config	m¥spring8.prm 📃 🚺
Accelerator Specificatio	n	and the the the the test of test o
Storage Ring		
Bunch Profile: Gaussi Electron Energy (GeV) Average Current (mA) Circumference Bunches σ _Z (mm) Peak Current (A) Natural Emittance (ma Coupling Constant ε _x (m.rad) 3.393e-009	an	Energy Spread 0.001 βx(m) 22.58 αx 0 βy(m) 5.61 αy 0 ηx(m) 0.11 ηx' 0 status y' 0 0 status y' 0 0 67.5% complete y'(µrad) 12.26 γ× 5y' 0.01722
Light Source Descriptio	n -Field Table	
✓ Link Gap & Field Segmented Undulat Gap Value B(T) Periodic Length (cm) Total Length (m) Number of Periods K Value ɛ1st(eV)	or 9.15509 0.736295 3.2 4.5 140 2.2 5553.42	$\begin{array}{c c c c c c c c } \hline \sigma_r(\mu m) & 3.55916 & \sigma_r'(\mu rad) & 4.99171 \\ \hline \Sigma_X(\mu m) & 297.878 & \Sigma_X(\mu rad) & 13.236 \\ \hline \Sigma_y(\mu m) & 7.12316 & \Sigma_y'(\mu rad) & 5.11144 \\ \hline \varepsilon_{1st}(peak:eV) & 5544.02 & \\ \hline \varepsilon_{3rd}(peak:eV) & 16647.8 & \\ \hline \varepsilon_{3rd}(peak:eV) & 16647.8 & \\ \hline Flux_{1st} & 8.95463e+014 & \\ \hline Brilliance_{1st} & 1.58007e+020 & \\ \hline Peak Brilliance & 6.19721e+021 & \\ \hline Bose Degeneracy & 0.0287544 & \\ \hline Total Power (kW) & 9.83453 & \\ \hline \end{array}$

General Instruction (4)

- 10. The calculation results are saved in a file with the name you specified and a suffix specific to the calculation type.11. To verify the calculation results graphically, select the data
 - name and items to be plotted, then click "Plot".

Eile Select Calculation	¥TT¥wx¥spectra9.0¥pi Run Open Utility Confis	m¥spring8.prm	PLOT: C:¥TT¥wx	/spectra9.0¥code_check¥test3	
-Accelerator Specificati	on				-
Storage Ring			10 ¹⁸ —	F.Density	
Bunch Profile: Gauss Electron Energy (GeV Average Current (mA) Circumference Bunches σ_z (mm) Peak Current (A) Natural Emittance (m. Coupling Constant ϵ_x (m.rad) 3.393e-009	ian	Energy Spres $β_x(m)$ 22 $β_y(m)$ 5. $η_x(m)$ 0. $η_y(m)$ 0 $1/\gamma(\mu rad)$ $\sigma_x(\mu m)$ $\sigma_y(\mu m)$ 0 $\gamma(\sigma_{x'}$ 0.1	10"- <u>Ais</u> 10"- 10"- 10"- 10"-		-
Light Source Descriptio	on -Field Table			10° 10° Energy	
Link Gap & Field Segmented Undula Special Magnet Se	tor tup	σ _r (μm) 3.5 Σ _X (μm) 29	23 (terror) 10		
Gap Value	9.15509	$\Sigma_{\rm y}(\mu m) = 7.123$	5544.02 5544.02	Add Remove Clear Plot List	
B(T)	0.736295	ε _{3rd} (peak:eV)	16647.8	Calast Data Nama	
Periodic Length (cm)	3.2	Flux _{1st}	8.95463e+014	C:\TT\wx\spectra9.0\code check\test3	
Total Length (m)	4.5	Brilliance _{1st}	1.58007e+020	Select File Name Select Y Axis	
Number of Periods	140	 Peak Brillance Bose Degeneral 	cv 0.0287544	test3.dc0 Energy	
K Value	2.2	Total Power (kV	V) 9.83453	F.Density Billionso	
ε _{1st} (e∨)	5553.42			PL45 Plot Import Clear Close	

TUTORIAL

- I. Spectrum
- II. Modifying the Conditions
- **III.Spatial Profile**
- IV.Brilliance Curve
- V. Scanning a Parameter
- VI.Any Other?

I. Spectrum

- Calculate the partial flux of SR passing through a rectangular slit.
- The output file of SPECTRA is an easyto-read text file. Open it with a text editor to check the contents.
- Create a plot to visualize the output data.

II. Modifying the Conditions

- Change the width or height of the slit to see how it broadens the spectral profile.
- Change the position of the slit to see how it changes the spectral profile.
- If you find any peculiar profile, increase the accuracy level.
- Learn how to create a "calculation process" to do successive calculations.
- Learn how to create a "multiplot" to compare more than one calculation results.

III. Spatial Profile

- Calculate the angular profile of the photon flux density.
- Change the photon energy to be fixed to see how the profile changes according to "detuning" (energy shift).

IV. K Dependence

- Calculate the flux and power as a function of the K value. This corresponds to the undulator gap motion.
- Learn the difference between "Fixed" energy and "Peak" energy.
- Add a spectrum plot to clarify the meaning of "Peak" energy calculation.

V. Scanning a Parameter

- "Scanning a parameter" is an option to specify more than one calculations with a specific parameter being changed.
- All the calculations are processed in sequence.
- An animation can be created by a post processor.

VI. Any Other Examples?

Now, let me know your requests on SR computation.

Documentation

- PDF-formatted instruction manual (spectra_reference.pdf) is placed in "[SPECTRA]/help" directory.
- HTML-formatted help files are also available, which can be viewed by running the [Help]-[Help] command.