Phaethon

Userguide

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1 Source code

The source code can be copied from the directory:

/home/athena/spxstd/phaethon

This folder contains current and previous versions of the code in the format:

nphaethon.year.month.day.tar

Copy the latest version to your space and then

tar xvf nphaethon.year.month.day.tar

This command will create a directory nphaethon , with the following files and subdirectories

nphaethon	
Name	**Description**
Makefile	
makefiletai.mk	
params.dat	general parameters, including flow control, ambient and stellar radiation field, SEDs and intensity maps
params.grid.dat	parameters relating to the grid construction
main	directory containing the main code routines
exec	directory where executables and required files are put
grid.spherical	contains the routines for constructing the grid, and grid related routines, e.g. advance photon, find photon cell, find photon origin, grid density profile
isrf	contains the data for the ambient radiation field
opacity.OH5_0.1_200	contains the opacity tables for OH5 opacity. The tables are constucted for temperatures up to 200K, with temperature resolution of 0.1 K
utils	various routines for analysing results
userguide	contains the userguide

2 Building and running the code

After you configure Makefile to your liking you build the code by typing make. This will copy everything the code needs to run in the directory exec (including the sample files params.dat & params.grid.dat. To run the code move into exec and type phaethon. During your run there is information printed on the screen and the following output files are produced:

Output files	
File name	Description
`incells.dat`	information about the initial state of your system (eg. cells, density, temperature)
`outcells.dat`	information about the initial state of your system (eg. cells, density, temperature, energy absorbed per cell)
`Av.r.dat`	shows the optical visual extinction vs radius (for spherically symmetric cores
`restart.dat`	information needed when restarting a run
`step.info`	information about how long it takes the code to run
`sed.id.lbin.mbin`	SEDs for a specific photon id for a specific direction (lbin,mbin)
`iso.fs.id.lbin.mbin`	intensity maps for a specific λ (fs) photon id for a specific direction (lbin,mbin) (NXPIXELS $\times$ NYPIXELS)
`isodata.fs.id`	radial intensity profilesfor a specific photon id (this is only for spherically symmetric cores
`intercount.s`	
`fnum.star.0.dat`	
`fnum.star.cgs.0.dat`	

Photon ids	
id	Description
0	all photons are counted
1	only direct photons from the radiation source are counted (i.e. if they do not have any interaction at all with the system)
2	only photons coming from a part system are counted (set by R_ORIGIN in `params.grid.dat`)
3	only scattered photons are counted (just scattered!)
4	only reprocessed photons are counted (absorbed and maybe scattered)

Makefile			
Variable name	Description	Recommended values	S
CC	sets the c compiler	gcc	$\sqrt{}$
OPENMP	compile the paraller version	0: NO 1: YES	$\times$
OPTIMISE	optimisation level	3	?
PROFILE	sets the -p -pg flag for time profiling	0: NO 1: YES	?
MAIN_DIR	directory of the main code	$(PWD)/main	$\sqrt{}$
GRIDDIR	directory of the grid making code	$(PWD)/grid.spherical	$\sqrt{}$
OPACITY_DIR	directory of opacity	$(PWD)/opacity.0H5_0.1_200	
ISRFD_IR	directory of the ambient radiation field		$\sqrt{}$
EXEC_DIR	directory to put executable and required files	$(PWD)/exec	$\sqrt{}$
Grid			
SPHERICAL	sets a spherically symmetric grid and adjusts code for better performance (note: other options maybe disabled when this flag is on)	0: NO 1: YES	$\sqrt{}$
DIM	refers to the 'dimensions' of the physical system 3: fully 3D system, 2: azimuthal and θ, -θ symmetry (e.g. flattened cloud, disc), 4: azimuthal symmetry	3, 2, 4	$\sqrt{}$
SEDs & Intensity maps			
NFBINS	number of frequency bins to put escaping photons	120	$\sqrt{}$
FS	number of wavelenghts to calculate intensity maps	1-10	$\sqrt{}$
NLBINS	number of polar angles (theta) to calculate intensity maps	1-10	$\sqrt{}$
NMBINS	number of azimuthal angles (phi) to calculate intensity maps	1-10	$\sqrt{}$
DO_ISOMAP	calculate SEDs and isophotal maps?	0: NO 1: YES	$\sqrt{}$
NBBINS	number of radial bins to calculate intensity (only for SPHERICAL case)	80	$\sqrt{}$
NXPIXELS	number of xpixels for intensity maps	128	$\sqrt{}$
NYPIXELS	number of ypixels for intensity maps	128	$\sqrt{}$
ISODIM	refers to the 'dimensions' of the appearence of the system (i.e. SEDs and intensity maps). The physical system maybe 3D but may look the same from different directions when viewed e.g. in long wavelengths. 3: fully 3D system, 2: azimuthal and θ, -θ symmetry (e.g. flattened cloud, disc), 4: azimuthal symmetry	3, 2, 4	$\sqrt{}$
EXTRA_SYMMETRY			$\times$
SPHERICAL_ISOMAP	calculates intensity maps assuming that the system is spherically symmetric (it just makes radial bins and computes averages)	0, 1	?
SPHERICAL_SED	calculates SEDs assuming that the system looks the same from all viewing angles (counting all available photons)	0, 1	$\sqrt{}$
Other options			
NO_INTERACTION	photons escape without any interactions (for testing)	0: NO 1: YES	$\sqrt{}$
MULTIPLE_PHOTONS			$\times$
TREE_INFO_OUT			$\times$
INFO_OUTPUT	output info as photon propagates (for testing)		$\sqrt{}$
NO_OPA_TABLE	there is an opacity equation not a table		$\times$
DUST_MIX	use 2 types of dust		$\times$
INC_SHADOW_PHOTONS			$\times$
LENGTH_UNIT	length unit for inputing in params.dat and params.grid.dat	PC or AU	$\sqrt{}$
SPH_SIMULATION	RT in SPH snapshots		$\times$

Variable name	Description	Value(s)	S
`params.dat` (I)
Variable name	Description	Value(s)	S
Control options
OUTPUT_FACTOR	how often to output data (in units of total photon number)	0.1	√
RESTART	is the run a restart?	0: NO 1:YES	√
MORE	is the run adding another luminosity source to existing run?	0: NO 1:YES	√

Variable name	Description	Value(s)	S
`params.dat` (II)
Variable name	Description	Value(s)	S
Ambient radiation field
ISRF	is there an ambient radiation field	0: NO 1:YES	√
ISRF_NPACKETS	number of ambient radiation field photon packets to use	10^8	√
R_ISRF==R_MAX	are ambient photons injected from cloud radius	0: NO 1:YES	√
R_ISRF	radius from which ambient photons are injected from (if above is 0) (pc or AU)	0.3	√
ISRF_MULTIPLY	value you multiply ambient radiation field (to weaken or strengthen)	1	√
ISRF_IGNORE_SCATTER	ignore ISRF scattering photons when making SED	1	√
STAR_ISRF_TEMP	temperature of the star-like (blackbody) ambient field	20	?
DILUTION	STAR_ISRF :: value you multiply star-like ambient radiation field	1	?
Stellar radiation field
MANUAL_STAR	include an extra star in the simulation?	0: NO, 1: YES	√
MANUAL_STAR_TYPE	type of star included (star.type)	0: star in the centre of coordinates 3: star outside cloud	√
STAR_NPACKETS	number of stellar photons to use	10^7	√
STAR_RADIUS	star radius (in solar radii)	1-3	√
STAR_X	star x-location (pc or AU)	0	√
STAR_Y	star y-location (pc or AU)	0	√
STAR_Z	star z-location (pc or AU)	20000 AU	√
STAR_MASS	star mass (in solar masses)	0	√
STAR_TEMP	star temperature (K)	6000	√

Variable name	Description	Value(s)	S
	params.dat (III)		
	SED & Intensity maps parameters		
DISTANCE	distance of the object (from Earth, in pc)	2000	$\checkmark$
DTHETA	tolerance angle from observer's line-of-sight to count photons $[0, 1]$ (in units of π)	0.05	$\checkmark$
SL1	lower λ (in μm) of placing escaping photons in λ-bins	0.005	$\checkmark$
SL2	upper λ	4000	$\checkmark$
F0	$1^{\text{st}}\lambda$ to calculate intensity map	10	$\checkmark$
F1	$2^{\text{nd}}\lambda$	850	$\checkmark$
F2	$3^{\text{rd}}\lambda$		$\checkmark$
F3	$4^{\text{th}}\lambda$		$\checkmark$
F4	$5^{\text{th}}\lambda$		$\checkmark$
F5	$6^{\text{th}}\lambda$		$\checkmark$
F6	$7^{\text{th}}\lambda$		$\checkmark$
F7	$8^{\text{th}}\lambda$		$\checkmark$
F8	$9^{\text{th}}\lambda$		$\checkmark$
F9	$10^{\text{th}}\lambda$		$\checkmark$
XMIN	minimum x coordinate of intensity map (in pc or AU)		$\checkmark$
XMAX	maximum x		$\checkmark$
YMIN	minimum y		$\checkmark$
YMAX	maximum y		$\checkmark$
THETA0	$1^{\text{st}}\theta$ of observer to calculate intensity map		$\checkmark$
THETA1	$2^{\text{nd}}\theta$		$\checkmark$
THETA2	$3^{\text{rd}}\theta$		$\checkmark$
THETA3	$4^{\text{th}}\theta$		$\checkmark$
THETA4	$5^{\text{th}}\theta$		$\checkmark$
THETA5	$6^{\text{th}}\theta$		$\checkmark$
THETA6	$7^{\text{th}}\theta$		$\checkmark$
THETA7	$8^{\text{th}}\theta$		$\checkmark$
THETA8	$8^{\text{th}}\theta$		$\checkmark$
THETA9	$10^{\text{th}}\theta$		$\checkmark$
PHI0	$1^{\text{st}}\phi$ of observer to calculate intensity map		$\checkmark$
PHI1	$2^{\text{nd}}\phi$		$\checkmark$
PHI2	$3^{\text{rd}}\phi$		$\checkmark$
PHI3	$4^{\text{th}}\phi$		$\checkmark$
PHI4	$5^{\text{th}}\phi$		$\checkmark$
PHI5	$6^{\text{th}}\phi$		$\checkmark$
PHI6	$7^{\text{th}}\phi$		$\checkmark$
PHI7	$8^{\text{th}}\phi$		$\checkmark$
PHI8	$9^{\text{th}}\phi$		$\checkmark$
PHI9	$10^{\text{th}}\phi$		$\checkmark$

params.dat (IV)			
Variable name	Description	Value(s)	S
Dust parameters			
DUST_TEMP	Dust destruction temperature (in K)	1200	
SCATTER_MULTIPLY	multiply scattering opacity ($k_s cat$) by this factor	1.0	
G_SCATTER		0.5	
Propagate photons			
STEP_MFP			
STEP_DENS			
STEP_R			
STEP_CELL			
INNER_STEP_SIZE			

```
grid.1
```

Prestellar/protostellar cores (3 types of geometries: spherical, flattened, comet-like, with/without disc around the protostar), with/withouth jets. Discs can work independently (by setting `ENVELOPE` to 0).

grid :: params.grid.dat			
Variable name	Description	Value(s)	S
Cloud/Core parameters			
CDENS0	central density (in cm^{-3})	10^5	$\checkmark$
R0	flattening radius (in AU or PC, as set in `Makefile`)	0.3	$\checkmark$
R_MAX_CORE	size of core (in AU or PC)	0.5	$\checkmark$
R_MAX	size of core and ambient cloud (sets auto to 0 if MC-CELLS=0) (in AU or PC)	0.7	$\checkmark$
R_ORIGIN	radius within which photons are counted with id=2	0.5	$\checkmark$
DENS_EXT_FACTOR	ratio of cloud density to the core density at R_MAX_CORE	0.8	$\checkmark$
R_DUST	size of the innermost cell (in units of R_MAX_CORE)	0.01	$\checkmark$
MU	mean mocular weight	2.3	$\checkmark$
BECELLS	number of radial cells-1 to divide the core (≥ 2)	102	$\checkmark$
MCCELLS	number of radial cells to divide the ambient cloud (≥ 0)	10	$\checkmark$
NLCELLS	number of polar cells-1 to divide the cloud (≥ 2)	10	?
NMCELLS	number of azimuthal cells-1 to divide the cloud (≥ 2)	10	$\checkmark$
LINEAR	radial cells have 1: equal widths 0: equal log widths	0 or 1	$\checkmark$
ISOANGLES	polar cells have 1: equal angles 2: equal cosines	0 or 1	$\checkmark$
FTAU_POINTS	number of points to use to calculate τ_{visual} for the cloud & core	1000	$\checkmark$
GEOMETRY	1: spherical cloud, 2 : flattened cloud, 3: comet-like cloud	1, 2, 3	$\checkmark$
SIN_POWER	Sine exponent (p) in the density profile	1, 2, 4	$\checkmark$
ASYMMETRY_FACTOR	Relates to A and sets how pronounces the asymmetry is	$>= 1 \, \& \, < 3$	$\checkmark$
Disc around central star parameters			
DISC	is there a disc around the central source?	0: No, 1: Yes	$\checkmark$
DISC_CDENS0	Disc density at 1AU from the central source (cm^{-3})		$\checkmark$
DISC_THETA_OPENING	Up to what angle (in units of DISC_ALPHA, from the midplane) the disc extends	$2 - 5$	$\checkmark$
DISC_R	Size of disc (in AU)	$5 - 100$ AU	$\checkmark$
DISC_ALPHA	thickness-to-radius ratio (z/R) of the disc		$\checkmark$
DISC_AMBIENT_DENS	the density at angles (theta) outside DISC_THETA_OPENING*DISC_ALPHA		?
DISC_INNER_GAP	Size of the gap around the central source in AU (this is always >= the dust destruction radius)	$0.1 - 2$ AU	$\checkmark$
DISC_INNER_GAP==R_DUST	Set the inner disc gap the same as R_DUST?		$\checkmark$
Jet from central star parameters			
JET	Is there a jet from the central star?	0: No, 1: Yes	$\checkmark$
JET_DENS	Density in the the jet cavity(cm^{-3})	10^3	$\checkmark$
JET_BETA		3	$\checkmark$
JET_THETA	(in unit of π)	0.027	$\checkmark$

SPHERICAL CLOUD

$$n = n_0 \; \frac{1}{1 + (r/R_0)^2} \tag{1}$$

n_0: CDENS0
R_0: R0

FLATTENED CLOUD

$$n(r, \theta) = n_0 \frac{1 + A \left(\frac{r}{R_0}\right)^2 [\sin(\theta)]^p}{\left[1 + \left(\frac{r}{R_0}\right)^2\right]^2} \; . \tag{2}$$

n_c is the the density at the centre of the core, and r_0 the scale length. A is a factor that determines the equatorial-to-polar optical depth ratio e (i.e. the optical depth from the centre to the surface of the core at $\theta = 90$ divided by the optical depth from the centre to the surface of the core at $\theta = 0$) , see page 84 of my thesis.

p: SIN_POWER
E: relates to A