Photolonization Governed Light Emulation Tool (PIGLET)

User manual

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System requirements

PIGLET general system requirements are Linux/Unix machines with gfortran/f95 installed. Any text editor (vi, gimp etc.) will be suitable to edit the input files. Fast fourier transform library providing subroutines such as rfftf and rfftb is delivered with the PIGLET. If necessary, fast fourier code can be compiled separately from PIGLET.

Warranty

The PIGLET comes with absolutely no warranty. Authors are not responsible for whatever damage, including damage to scientific reputation, this program might cause. Efforts were made to make the program stable. However, it is definitely possible to choose a set of parameters for which the program will give wrong results, senseless results, or simply crash. Treat this program not as a foolproof product, but more as an experimental setup, which can give all kinds of results depending on handling.

License agreement

The PIGLET can be used in any way (including modification of the program) for any needs of the members of ATLANTIC RISE project consortium. Beyond that, PIGLET can be used for non-commercial purposes by the persons whom the access was granted, provided that they

do not modify and/or redistribute it, and provided that PIGLET is properly referenced in any scientific publication originating from its use.

Setup

1. Unzip the installation archive (tar -xf piglet.tar) in your working directory.
2. Make the file compile.sh executable (chmod 770 compile.sh).
3. Run the compile.sh (./compile.sh). Several runs may be required. Ignore the warnings. Check that the executable file a.out has been created.
4. To run the program, run a.out (./a.out).

Input files

Input files are:
input.dat, structure.dat, materials.dat, aux.dat.

Input files must contain the following number of lines:

input.dat	5
aux.dat	2
structure.dat	1+3*N_el
materials.dat	1+9*N_mat

where N_el is the number of structure elements along the propagation coordinate, and N_mat is the number of defined materials.

All the parameters must be set, there are no default values. Including less than above-indicated number of lines will produce an error; including more lines will lead to excess lines being ignored. Each of the lines should contain the required value in the first position, followed by an optional comment which will be ignored. Almost all values, with an exception of the ionization potential, are defined in SI units. The parameters can be given using the floating-point notation: e.g. 5d-5 means to $5x10^{-5}$.

input.dat

File input.dat must contain 5 lines which define various parameters related to input pulse and the photoionization model, as shown in the following table:

Line number	Integer/real	Units	Meaning
1	real	W/m^2	Input peak intensity
2	real	s	FWHM duration of input pulse
3	real	m	Central wavelength of the input pulse
4	integer	-	Flag which selects ionization model: 1 Multiphoton 2 ADK 3 IY

5	integer	-	Flag which selects the input pulse envelope: 1 Gaussian 2 $\cos^2$

structure.dat

File structure.dat describes the structure of the system. A 1D plane-parallel system is considered, which contains Nel layers (with a minimum of 1), with Nel provided in the first line of structure.dat. For each of the layers, 3 parameters are given, so that the total number of the lines to be included in structure.dat is 1+3*Nel. The vacuum or air before the structure is not considered as a layer.

Line number		Integer/real	Units	Meaning
1		Integer	-	Number of layers Nel
x Nel	2	Real	m	Coordinate of the layer beginning
	3	Real	m	Coordinate of the layer end (larger than the coordinate of the layer beginning)
	4	Integer	-	Integer material identifier, as defined in the materials.dat

Note: if the layers overlap, the latter ones overwrite the former ones.

materials.dat

File materials.dat contains 1 + 10xNmat lines, where Nmat is the number of the defined materials (with a minimum of 1), with Nmat provided in the first line of materials.dat. For each of the materials, 10 parameters are given, so that the total number of the lines to be included in materials.dat is 1+10*Nel. This file includes integer material identifiers, going from 1 to Nmat, which should be used in the file structure.dat.

Line number		real/integer	Units	Meaning
1		Integer	-	Number of different materials
X nmat	2	Integer	-	Material identifier
	3	Real	eV	Ionization potential
	4	Real	-	Effective mass in the conduction zone relative to the free-electron mass
	5	Real	m^{-3}	Concentration of the material structural elements (atoms, molecules etc). Each of such structural elements can be ionized to produce one electron.

	6	Real	-	Linear dielectric function
	7	Real	-	Number of periods used to calculate intensity for the Ivanov-Yudin model. Unused for other models
	8	Real	s^{-1}	Decay rate of conduction-electron motion
	9	Real	W/m^2	Intensity of a pulse corresponding to an experimental damage threshold
	10	Real	s	Duration of a pulse corresponding to an experimental damage threshold
	11	Real	m	Wavelength of a pulse corresponding to an experimental damage threshold

Note: from the parameters characterizing the damage threshold, the correction factor for the ionization-rate formula, in the formalism defined as defined by line 4 of input.dat, is calculated. The ionization rate will be multiplied by this correction factor. If this behavior is not desired, it is also possible to set the correction factor to any predefined value, including 1. To do that, set the intensity of a pulse corresponding to an experimental damage threshold to a negative value, with absolute value equal to the desired correction factor.

aux.dat

File aux.dat contains auxiliary parameters which normally do not have to be changed.

Line number	real/int	units	meaning
1	real	-	Ratio dx/(c*dt)
2	integer	-	Number of time points in threshold simulation

Output files

The following output files are provided upon a successful run of a program: info.dat, map.dat, relf.dat, transm.dat, and spectra.dat.

info.dat

File info.dat provides the following information about the parameters and the results of the simulation:

Line number	Parameter	Units
1	Correction factor for the ionization rate	-

2	step in time	s
3	step in space	m
4	number of points in time	-
5	number of points in space	-
6	Size of calculation box in space	m
7	Number of point in space corresponding to the lower boundary of the slab	-
8	Lower boundary of the slab	m
9	Higher boundary of the slab	m
10	Squared ratio of the plasma frequency at full ionization to pump frequency	-
11	Input pulse energy	arb. units (same for lines 11-14)
12	Reflected pulse energy	arb. units (same for lines 11-14)
13	Transmitted pulse energy	arb. units (same for lines 11-14)
14	Absorbed pulse energy	arb. units (same for lines 11-14)
15	Maximum plasma density	m^{-3}

Some of these parameters are also written to the standard output during the execution of the code.

map.dat

The file map.dat contains full propagation information.

Line number	Real/integer	Units	Meaning
1	integer	-	Number of point in space
2	integer	-	Number of point in time
3	real	-	Electric field at the given point in space and time, divided by the maximum electric field of the input pulse
4	real	-	Magnetic field strength H at the given point in space and time, divided by the maximum electric field of the input pulse
5	real	C/m^2	Polarization at the given point in space and time
6	real	$1/m^3$	Plasma density at the given point in space and

			time

Note: to facilitate plotting using gnuplot software, an empty line is added between the lines corresponding to different values of the point number in space.

refl.dat and tran.dat

Files refl.dat and tran.dat contain the information about the reflected and transmitted pulses, respectively. The are both have the same structure:

Line number	Real/integer	Units	Meaning
1	integer	-	Number of point in time
2	real	V/m	Electric field at the given point in space and time

spectra.dat

File spectra.dat contains the spectral amplitudes and phases of the reflected and transmitted pulses. Note that the phases are calculated with the maximum of each pulse shifted to time position zero. The file has the following structure:

Line number	Real/integer	Units	Meaning
1	real	s^{-1}	Frequency divided by central pump frequency
2	real	V	Amplitude of the spectrum of the transmitted pulse
3	real	V	Amplitude of the spectrum of the reflected pulse
4	real	-	Phase of the spectrum of the transmitted pulse
5	real	-	Phase of the spectrum of the reflected pulse