

inserexs user guide

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1. PROGRAM DESCRIPTION:

inserexs has been written in Python 3.9 language and has been tested on Windows 10 and Ubuntu 20.040 LTS. It has also been adapted for Mac users but has not been tested so far. *inserexs* consists of three different modules and a graphic interface.

- main.py: backbone, direct exchange with interface.
- intensity module.py: module for the calculation of the reflection intensities.
- sensitivity module.py: module for the calculation of the reflection sensitivities.

2. GENERAL SET-UP:

For the correct running of the *insexs* code, the following Python packages (not included in the standard version of Python 3.9) should be installed. The versions used in the conception and trial of the code are indicated.

- numpy – 1.21.5
- matplotlib – 3.5.1
- PyQt5 – 5.14.4
- promptlib – 3.0.20
- threading – 4.1.0
- scipy – 1.10.11
- pandas – 1.4.2
- sympy – 1.10.11

The three .py modules that compose the code, as well as the interface and the icon image, should be present in the same directory. Furthermore, two additional directories should be present:

- a. A “FDMNES” folder, from where the fdmnes code will be launched. The “fdmnes_win64.exe” file should be present in this folder for Windows systems, and the “fdmnes_linux64” file for Linux. The fdmnes software should be downloaded from its original source: [Download - The FDMNES project](#)
[FDMNES download: package with executables, manual and input file](#)

[examplesThe FDMNES project \(cnrs.fr\)](#) and then moved to this folder. Another option would be to explicitly indicate the location in the code itself.

UPDATE: for linux users, an error can occur if FDMNES does not have the proper permissions. If an error arises, please check that FDMNES can be run normally.

- b. A “Sasaki anomalous” folder, which contains the data from the International Tables of Crystallography that are needed for the calculation of the atomic scattering factors.

Some folders will be automatically created inside the “FDMNES” folder for the communication of the *inserexs* program and *fdmnes*. This folder will also contain the “FileResults” folder which stores all the output files for the simulation as well as the final “Sensitivity vs. Intensity” plot image.

3. RUNNING INSTRUCTIONS

- i. Once the *main.py* module is executed, the interface windows should pop up.
- ii. From there, the user must press the “Load .cif file” button. A pop-up window will then appear, letting the user choose the .cif file which contains all the crystal information. The requirements that the .cif file must respect are indicated in part...

- If the user wants to change any crystallographic data, they can do it from the interface. After any modification the “Update” button should be pressed.
- iii.** A maximum value for the h, k and l Miller parameters of the generated reflections should be introduced. The default value (2) is useful for quick simulations but might be too small for real uses.
- If the user wants to consider the forbidden reflections (some of them active in REXS), they can check the “Include forbidden reflections” checkbox.
- iv.** After pressing the “Fetch active reflections” button, the reflections are generated.
- v.** From the “Atomic information” table, the parameters of interest (atomic positions or occupation) should be chosen. If the chosen parameter does not respect the crystal symmetry (e.g. refinement of a fixed special position) fdmnes will laterly raise an error.
- vi.** The different conditions for the fdmnes simulations should be filled in: the energy start, the energy step and the energy stop around the edge. The edge for simulation should be chosen in the “Atom” table. The default parameters are suitable for quick simulations but longer ranges are more convenient for most simulations.

- The user has the possibility to make all the chosen parameters vary simultaneously (coupling) or independently (not coupling) by checking the “Couple refinement parameters” checkbox.
- vii.** The “Launch simulation” button will run the `fdmnes` program.
- viii.** Once the simulation process finishes, the “Sensitivity vs. Intensity” button makes a plot of the calculations and outputs a `.png` file in the “FileResults” folder.

4. DATA INPUT

As previously mentioned, the data input takes place in the form of a `.cif` file. *inserexs* has been tested in a wide range of `.cif` file of different materials, space groups, document styles and sources. A showcase `.cif` file could be the following (in red, the mandatory parts for the crystal information detection):

```
#-----
# $Date: 2017-10-06 19:24:22 +0300 (Fri, 06 Oct 2017) $
# $Revision: 201816 $
# $URL: file:///home/coder/svn-repositories/cod/cif/9/01/46/9014668.cif $
#-----
# This file is available in the Crystallography Open Database (COD),
# http://www.crystallography.net/. The original data for this entry
# were provided the American Mineralogist Crystal Structure Database,
```

```
# http://ruff.geo.arizona.edu/AMS/amcsd.php

# The file may be used within the scientific community so long as

# proper attribution is given to the journal article from which the

# data were obtained.

#

loop__

__publ__author__name

'Xiao, C. J.'

'Jin, C. Q.'

'Wang, X. H.'

__publ__section__title

;

Crystal structure of dense nanocrystalline BaTiO3 ceramics

Note: phase T (tetragonal)

;

__journal__name__full      'Materials Chemistry and Physics'

__journal__page__first     209

__journal__page__last      212

__journal__paper__doi       10.1016/j.matchemphys.2008.01.020

__journal__volume          111

__journal__year             2008
```

_chemical_compound_source	Synthetic
_chemical_formula_sum	'Ba O3 Ti'
_space_group_IT_number	99
_symmetry_space_group_name_Hall	'P 4 -2'
_symmetry_space_group_name_H-M	'P 4 m m'
_cell_angle_alpha	90
_cell_angle_beta	90
_cell_angle_gamma	90
_cell_length_a	3.9988
_cell_length_b	3.9988
_cell_length_c	4.0222
_cell_volume	64.317
_database_code_amcsd	0018579
_exptl_crystal_density_diffn	6.021
_cod_original_formula_sum	'Ba Ti O3'
_cod_database_code	9014668
_amcsd_formula_title	BaTiO3
loop__	
_space_group_symop_operation_xyz	
x,y,z	
-y,-x,z	

-y,x,z

x,-y,z

-x,-y,z

y,x,z

y,-x,z

-x,y,z

loop__

__atom__site__label

__atom__site__fract__x

__atom__site__fract__y

__atom__site__fract__z

__atom__site__U__iso__or__equiv

Ba 0.00000 0.00000 0.00000 0.19600

Ti 0.50000 0.50000 0.50210 0.01800

O1 0.50000 0.50000 -0.01530 0.01700

O2 0.50000 0.00000 0.51300 0.01100

loop__

__cod__related__entry__id

__cod__related__entry__database

__cod__related__entry__code

1 AMCSD 0018579

#-----

For the space group, both the group's number or the name are accepted. The former is recommended in most cases to avoid any style difference. If a setting is needed, it should be indicated after a semi-colon (e.g. **227:2**)

5. ADDITIONAL INFORMATION

A more detailed description of the code and some general examples will be shown in a yet-to-come publication. This user guide will be expanded with visual examples when this publication is accepted.