PArthENoPE: Public Algorithm Evaluating the Nucleosynthesis of Primordial Elements

GUI User Manual

Authors: Rosa Consiglio, Ofelia Pisanti

GUI User Manual

CONTENTS

1. INTRODUCTION

Current research in the field of cosmology is based on a large amount of experimental observations in different fields. In particular, these include primordial nucleosynthesis, that is, the production of all light nuclides in the universe, through a network of nuclear processes triggered when the temperature of the plasma dropped from a few MeV down to about 10 keV. Big Bang Nucleosynthesis (BBN) is one of the main findings of the Hot Big Bang model, and is now used as an invaluable tool to indirectly test cosmological models, in order to better comprehend the universe we live in, as well as particle physics, improving our understanding of fundamental interactions. The program PArthENoPE, publicly available at `http://parthenope.na.infn.it/`, is one of the tools that helps researchers in understanding the variety of information that astroparticle physics provides. In particular, PArthENoPE computes the abundances of light elements produced during Big Bang Nucleosynthesis; starting from nuclear statistical equilibrium conditions, the program solves the set of coupled ordinary differential equations, follows the departure from chemical equilibrium of nuclear species, and determines their asymptotic abundances as a function of several input cosmological parameters as the baryon asymmetry, the number of effective neutrinos, the value of cosmological constant and the neutrino degeneracy parameters.

The PArthENoPE Graphical User Interface (GUI) has been created within the project *Astroparticle physics as a research tool for investigating the universe and fundamental interactions* [1]. Credits for this version of the GUI are shown by the **About** button on the Start page.

The GUI has been designed to make the program more user friendly. In fact, it enhances the old interface of the previous version of PArthENoPE, since it allows to produce in a very simple way the PArthENoPE configuration files (corresponding to the input cards needed in the "card mode" of the old version). In particular, the GUI now allows the user to execute either single runs with individual values of the physical parameters (as in the previous version) or to launch multiple runs on a user defined grid.

The GUI is structured in four sections, three of which are dedicated to the choice of the set of parameters (network and physical inputs) and features for customizing the output that can be chosen by the user. The fourth section allows the running of the code. On each page, the user can find a **Help** button which gives instructions on how to proceed. The user is

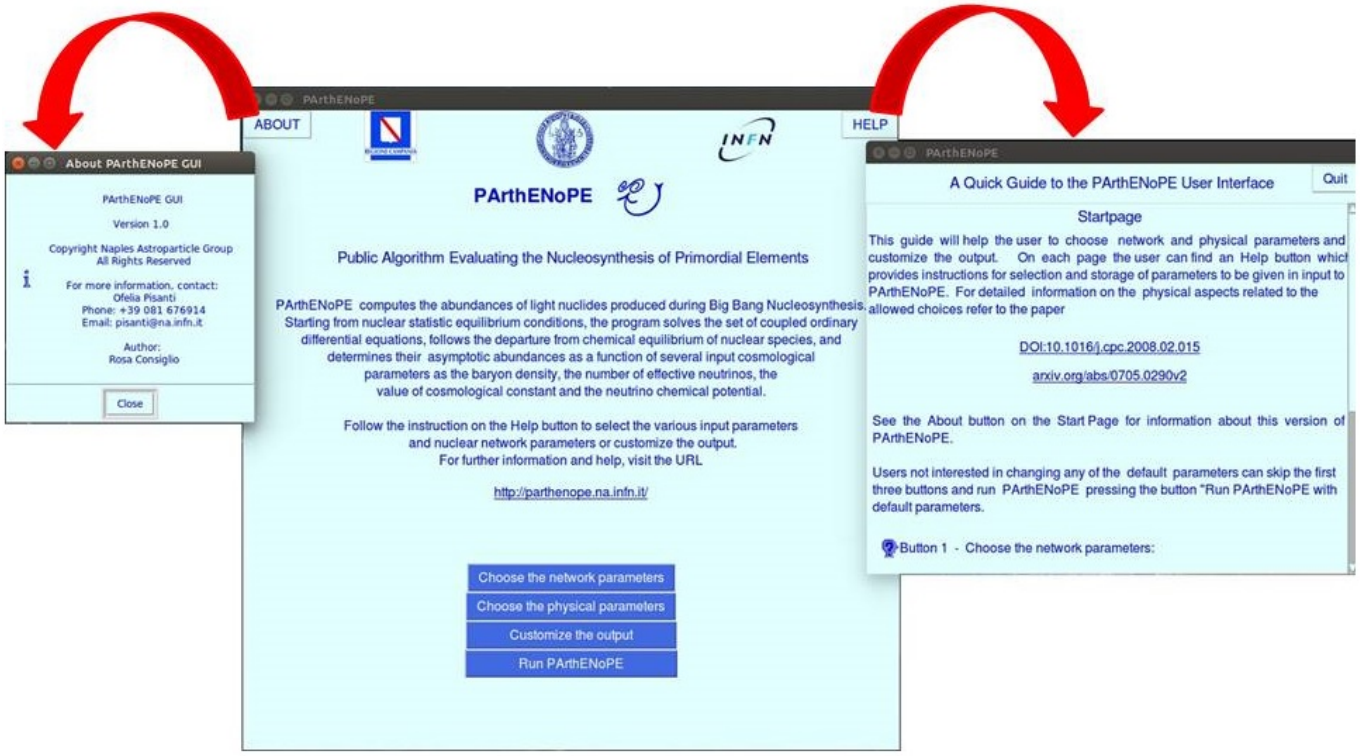

Figure 1: GUI Start page.

supported both in the usage of widgets (buttons, drop-down lists, text boxes, counters) and in the allowed choices of parameters by the quick guide provided on each page. In the absence of user's choices, the default values will be automatically selected for each of the options not carried out.

The GUI is implemented in Python. In order to run it the user needs a Python version 2.7 as well as application dependencies (libraries and modules): Tkinter, Pmw, ttk, Numpy and PIL.

For more detailed information on the physical issues related to PArthENoPE refer to the original PArthENoPE paper [2] and to Ref. [3]. Updated information on PArthENoPE and its GUI can be found in [4].

In order to avoid problems with outdated versions of PArthENoPE users are kindly asked not to distribute the program to any new users. Rather, it is warmly recommended to address new users to the PArthENoPE web page `http://parthenope.na.infn.it/` or, alternatively, to send their name and address to the address which follows. This allows new users to be provided with the latest version of the program, error corrections, and updates.

In case of problems in installing or running the program and the GUI, or comments regarding physics, computing, or handling, please contact:

Prof. Ofelia Pisanti
Università di Napoli Federico II
Email: pisanti@na.infn.it

Dr. Rosa Consiglio
Università di Napoli Federico II
Email: rosella.consiglio@gmail.com

2. INSTRUCTIONS FOR INSTALLATION

The PArthENoPE program and its GUI are distributed as a compressed (zipped) file containing the source and related files listed below:

- A file *readme.txt* listing the content of the package and brief instructions on how to proceed.
- Two FORTRAN files containing the main interface and program:
  - *parthenope*2.0.*f*
  - *main*2.0.*f*
- Four additional FORTRAN files containing the routines used by the main program:
  - *addon*2.0.*f*
  - *dlsode.f*
  - *odepack*1-*parthenope*2.0.*f*
  - *odepack*2-*parthenope*2.0.*f*
- Example shell files, *comp_linux* (Linux OS) and *comp_mac* (Mac OS), for compiling the code and producing the executable to be launched by the GUI. Note that these files should be recognized as executable by the operative system; if necessary, make them executable with the command `chmod +x comp_mac` or `chmod +x comp_linux`.
- An example configuration file *input*2.0.*card* (for compatibility reasons with the previous version).
- The Python files, *gui*2.0_*linux.py* and *gui*2.0_*mac.py*, containing the GUI for Linux or Mac OS.
- The archive files *images_mac.zip* and *images_linux.zip* with the image folder for Linux or Mac OS.

- Output files, *parthenope*2.0.*out* and *nuclides*2.0.*out*, obtained when the GUI runs with default parameters.
- A file *changelog*2.0.*txt* listing the changes with respect to the past versions.
- This manual, *GUIUserManual.pdf*, with instructions for the use of the GUI and the software.

First, the user has to unzip the file *images.zip* into the current working directory and compile the FORTRAN source files using the example shell file under Mac or Linux OS. At this point, the user can use the standard version of PArthENoPE2.0 calling the executable, *parthenope*2.0 (in interactive or card mode). Then, for using the GUI, follow the instructions below for the installation. At this regard, note that the *parthenope*2.0 executable and the Python file *gui*2.0.*py* have to be present in the same directory.

GUI installation instructions for Linux users

1. Check if Python 2.7 is already installed using the command

   ```
   python -V
   ```

   Otherwise, install Python 2.7.x from the website `https://www.python.org/ftp/python/2.7.6/` or from command-line (Debian/Ubuntu systems)

   ```
   sudo apt-get install python2.7
   ```

2. Install Python module (Debian/Ubuntu systems) Tkinter from command-line

   ```
   sudo apt-get install python-tk
   ```

3. Install ttk Themed widgets from the website `https://pypi.python.org/pypi/pyttk` or from command-line (Debian/Ubuntu systems)

   ```
   sudo apt-get install python-ttk
   ```

4. Install Python Imaging Library (PIL) from the website `http://www.pythonware.com/products/pil/` or from command-line (Debian/Ubuntu systems)

   ```
   sudo apt-get install python-imaging-tk
   ```

5. Install Pmw Megawidgets from the website `https://sourceforge.net/projects/pmw/files/` or from command-line (Debian/Ubuntu systems)

   ```
   sudo apt-get update
   sudo apt-get install python-pmw
   ```

6. Install Numpy from command-line (Debian/Ubuntu systems)

   ```
   sudo apt-get install python-numpy
   ```

GUI installation instructions for Mac OS users

1. Check whether Python 2.7 is already installed using the command

   ```
   python -V
   ```

   Otherwise, install Python 2.7.x from the website `https://www.python.org/downloads/mac-osx/` or from command-line

   ```
   brew install python
   ```

2. The Python module Tkinter is included in the standard Python distribution 2.7 on Mac OS X. We address the user to the page `https://wiki.python.org/moin/TkInter` for additional details.

3. Check whether the module `ttk` is present in Python using the command

   ```
   python -c "import ttk"
   ```

   If the system answer is something like

   ```
   Traceback (most recent call last):
   File "<string>", line 1, in <module>
   ImportError:  No module named ttk
   ```

   install `ttk`. Go to the website `https://pypi.python.org/pypi/pyttk`, download the archive file pyttk-0.3.2.tar.gz, decompress it, go into the corresponding directory and type the command

   ```
   sudo python setup.py install
   ```

4. Check whether the libraries `libjpeg` and `libpng` are present using the command

   ```
   locate libjpeg
   locate libpng
   ```

   Another way can be to run for example the command

   ```
   gcc -ljpeg
   ```

   If you get something like

   ```
   Undefined symbols:  "_main", referenced from:  ...
   ```

   `libjpeg` has been found. If instead you get something like

   ```
   ld:  library not found for -ljpeg
   ```

   install `libjpeg` and `libpng`. Go to the website `http://ethan.tira-thompson.com/Mac_OS_X_Ports.html`, click on the button "Combo Installer: libpng & libjpeg" to download the corresponding file `dmg`, open it, right click on the `mpkg` file, click on Open and accept the action in the following window.

5. Check whether the module `PIL` is present in Python using the command

   ```
   python -c "import PIL"
   ```

   If the system answer is something like

   ```
   Traceback (most recent call last):
   File "<string>", line 1, in <module>
   ImportError:  No module named PIL
   ```

   install `PIL`. Go to the website `http://www.pythonware.com/products/pil/`, download the file `Imaging-1.1.7.tar.gz` from the link "Python Imaging Library 1.1.7 Source Kit (all platforms)", decompress it, go into the corresponding directory and type the command

   ```
   sudo python setup.py install
   ```

6. Check whether the module `Pmw` is present in Python using the command

   ```
   python -c "import Pmw"
   ```

If the system answer is something like

```
Traceback (most recent call last):
File "<string>", line 1, in <module>
ImportError:  No module named Pmw
```

install `Pmw`. Go to the website `https://sourceforge.net/projects/pmw/files/`, download the file `Pmw-2.0.0.tar.gz`, decompress it, go into the corresponding directory and type the command

```
sudo python setup.py install
```

3. START PAGE

The PArthENoPE GUI is launched with the command: python gui2.0.py &

The Start page of the GUI provides the user with useful links for general information and four buttons for accessing each of the sections of which it consists.

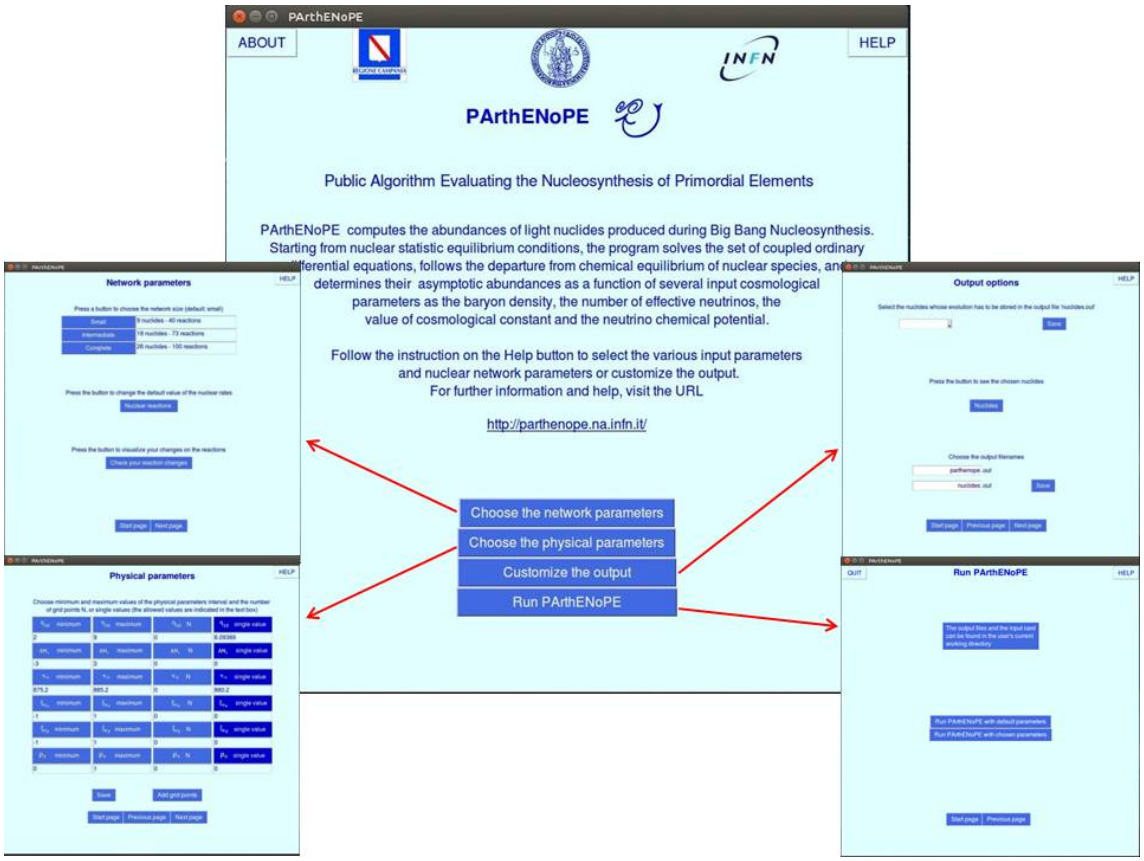

Figure 2: GUI Start page.

The user can run PArthENoPE with whatever set of chosen parameters (the allowed range of

values are displayed on the specific widgets) visiting the sections of interest, or skip the first three sections and use the fourth button which opens the window for launching PArthENoPE with default values of all parameters.

The Start page contains the following buttons:

- **Choose the network parameters** button.
  This button opens the **Network parameters** page, where the user can modify the default network parameters.
- **Choose the physical parameters** button.
  This button opens the **Physical parameters** page, where the user can modify the default physical parameters.
- **Customize the output** button.
  This button opens the **Output options** page, where the user can change the default output content and the file names.
- **Run PArthENoPE** button.
  This button opens the **Run PArthENoPE** page, where the user can start PArthENoPE run.

4. NETWORK PARAMETERS

This page allows the user to change the network parameters. In the absence of any user choice, the GUI will adopt the default configuration, consisting in the **Small** network with 9 nuclides and the default values of the corresponding 40 reactions.

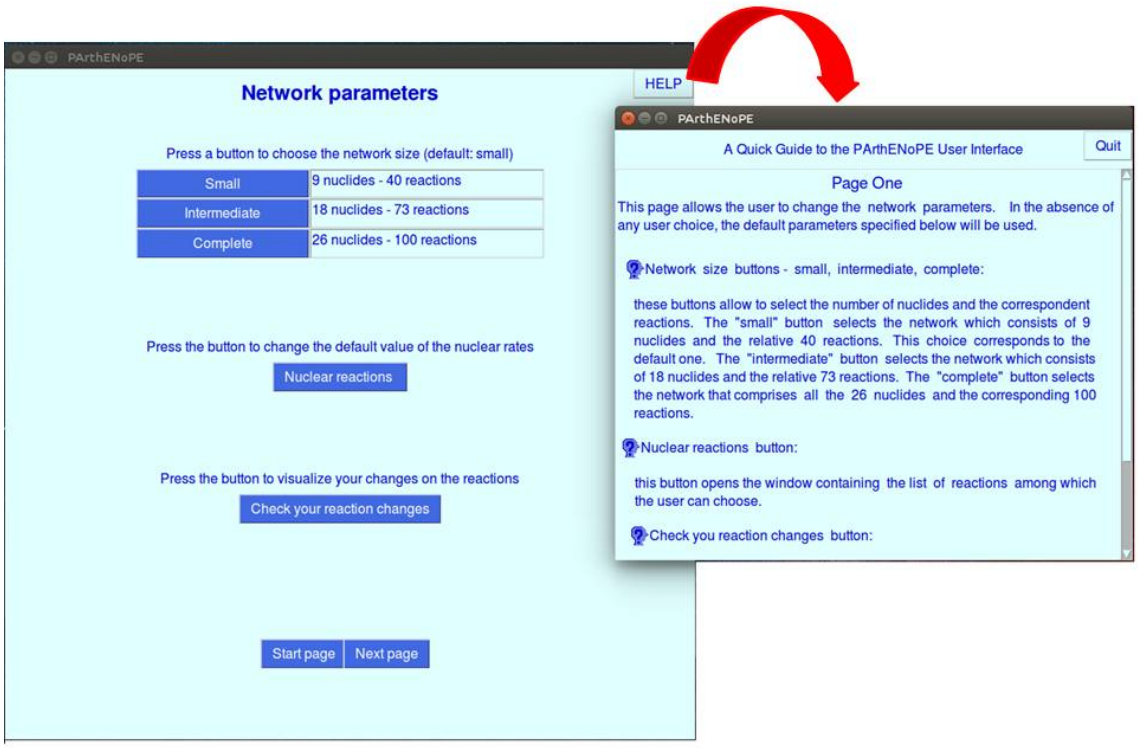

Figure 3: **Network parameters** page.

- Network size buttons - **Small**, **Intermediate**, **Complete**.
  The user can choose among **Small**, **Intermediate** or **Complete** networks by clicking the corresponding buttons (see Ref. [2] for details). The **Small** button selects a network which consists of 9 nuclides and the relative 40 reactions. The **Intermediate** button selects a network which consists of 18 nuclides and the relative 73 reactions. The **Complete** button selects a network that comprises all the 26 nuclides and the corresponding 100 reactions. This first choice corresponds to the default one.

- **Nuclear reactions** button.
  This button opens the **List of reactions** page, containing the list of all reactions (which depends on the type of network that is currently considered). The user can change the rate of any number of such reactions by selecting them from the drop-down list at the top of the page. Then, as summarized in the text at the center of the window, the user has to choose for each selected reaction the desired type of change among those displayed on the specific drop-down list at the bottom left. In case the third option of changing by a factor is chosen, the factor has to be entered by means of the counter widget (i.e. an entry field with arrow buttons to increment and decrement the current value or type a value in the allowed range). IMPORTANT: note that the implemented changes in the rates have to be saved one by one using the button **Save**. In particular:

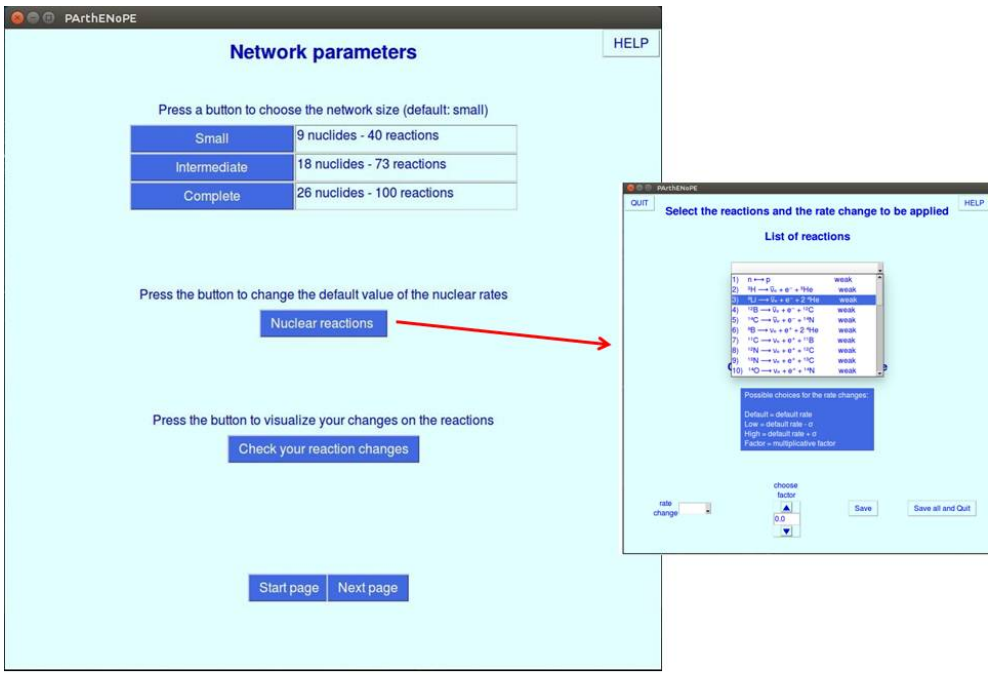

Figure 4: **Network parameters** page. The **List of Reactions** page opened by the **Nuclear reactions** button.

1. **Rate change**.
   This drop-down list allows the user to choose the type of rate change to be applied to the previously selected reaction. *Low* and *High* refer to rate uncertainties; in particular they correspond to add to the default rate $-\sigma$ or $+\sigma$ respectively. *Factor* corresponds to modifying the rate by a multiplicative factor chosen by the user (see Ref. [5] for details on the physics involved).
2. **Choose factor**.
   In the case that the user has chosen the *Factor* option in the **Rate change** drop-down list, this counter widget enables to select or type a value of the multiplicative factor in the range [0, 10].

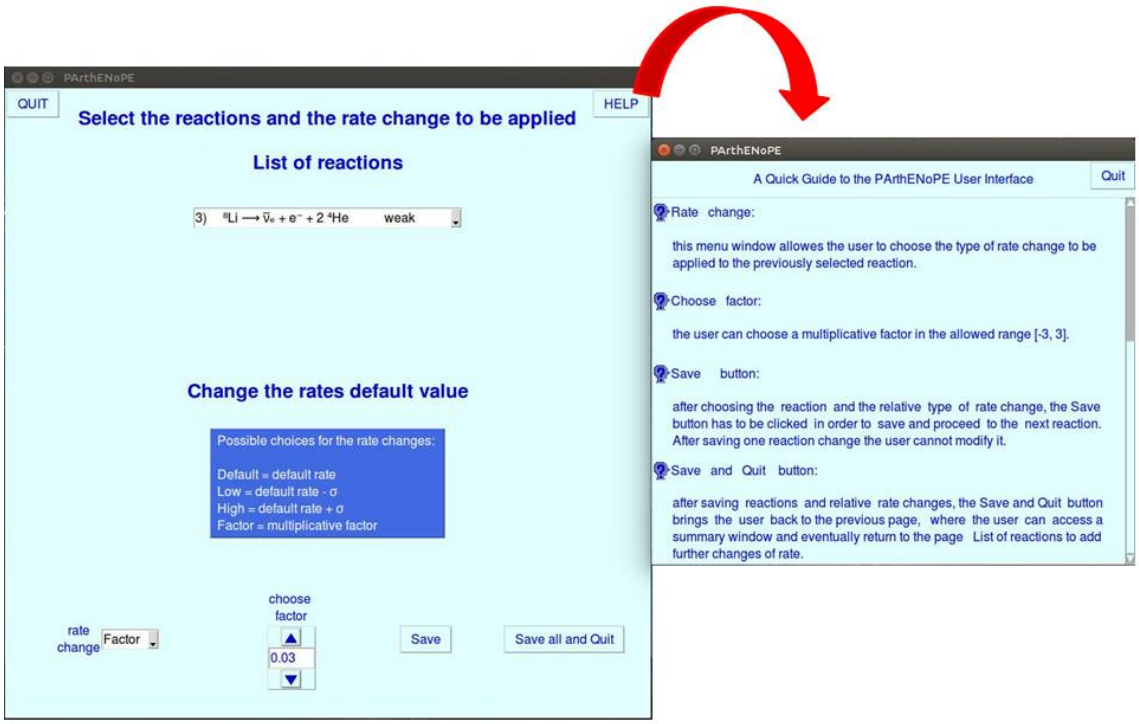

Figure 5: **List of Reactions** page.

3. **Save** button.
   After choosing a reaction and the relative type of rate change, the **Save** button has to be clicked in order to save and proceed to the next reaction. IMPORTANT: note that the user cannot modify a reaction change after having saved it.
4. **Save and Quit** button.
   Once completed the process of changing reaction rates, the **Save and Quit** button

brings the user back to the **Network parameters** page. If necessary, the user can return to the **List of reactions** page to add further changes in the rates.

- **Check your reaction changes** button.
  This button opens a window that summarizes the users' choices. The user is allowed to include additional reactions rate changes going back to the **List of Reactions** page.

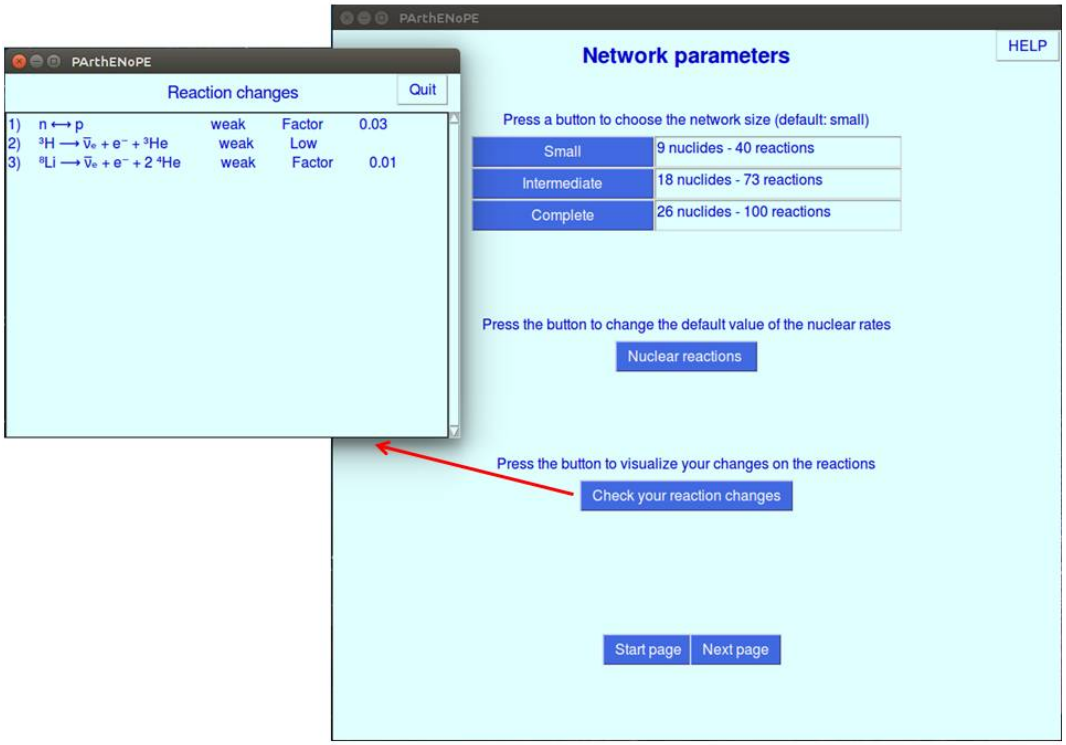

Figure 6: **Network parameters** page. Check window with the summary of the user choices.

- Navigation buttons.
  The buttons **Start page** and **Next page** allow the users to move backward to the initial page and forward to the next page.

5. PHYSICAL PARAMETERS

This page allows the user to change the physical parameters. It is possible to choose a single value or a grid of values for neutron lifetime, baryon asymmetry, effective number of neutrinos, neutrino degeneracy parameters, energy density of the vacuum at the BBN epoch.

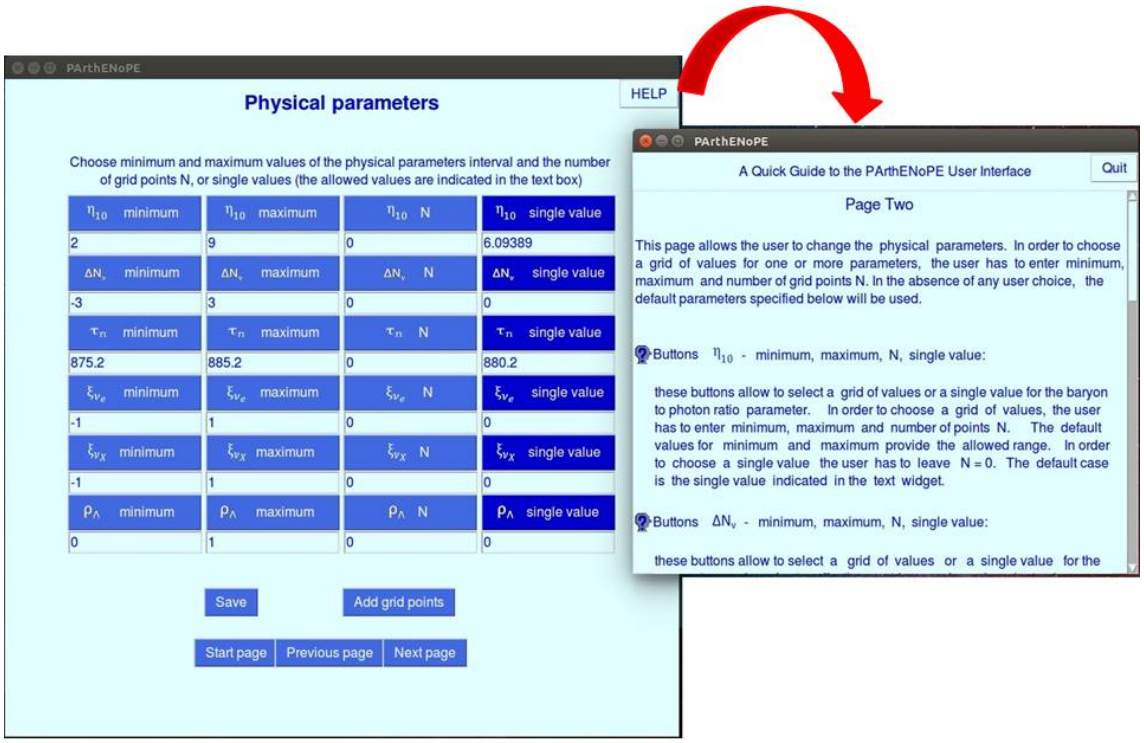

Figure 7: **Physical parameters** page.

For some or all of the physical parameters the user can choose single values and/or set an

equally spaced grid, by choosing the number N of grid points. Optionally, minimum and/or maximum values of the default range can be changed so as to obtain an interval contained in the one specified in the text widgets below the corresponding buttons.

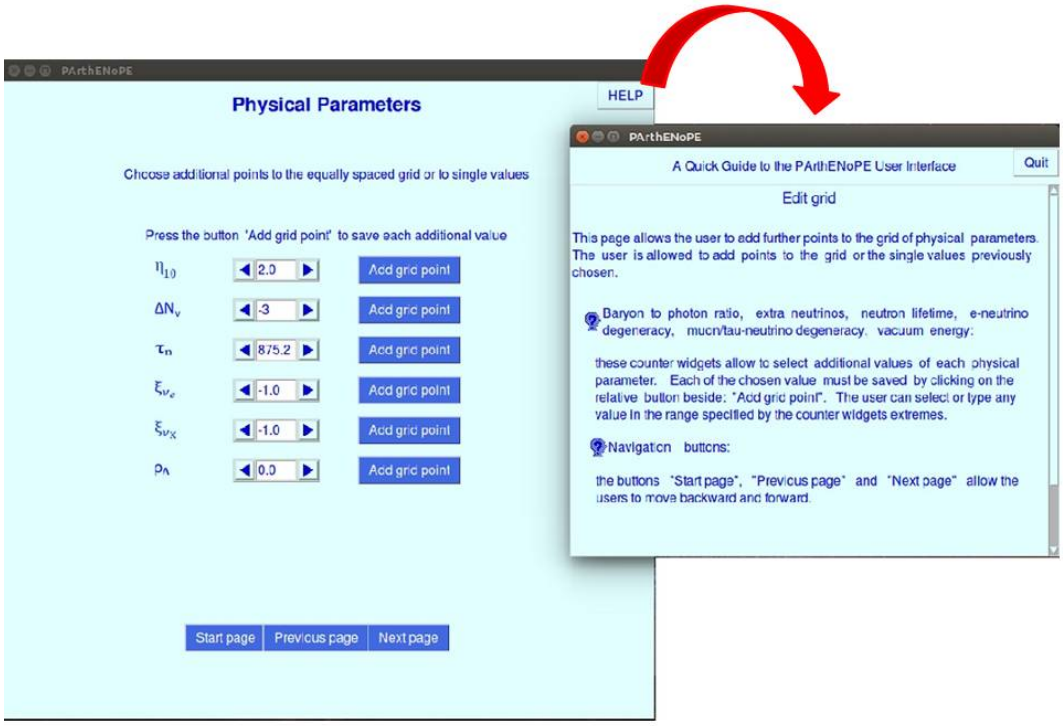

Figure 8: **Edit grid** page.

Further points can also be added to the grid or to the single values by clicking the specific button **Add grid points**. In the absence of any user choice, PArthENoPE will be run with the following single values: $\tau_n = 880.2$ s, $\eta_{10} = 6.094$, $\Delta N_\nu = 0$, $\xi_{\nu_e} = \xi_{\nu_x} = 0$, $\rho_\Lambda = 0$.

- **minimum**, **maximum**, **N**, **single value** buttons.
  These buttons allow to select a grid of values or a single value for the given physical parameter. In order to choose a grid of values for one or more parameters, the user has to enter the number of grid points, N, and optionally change the minimum and/or maximum for the interval in the allowed range. In order to choose a single value for one or more parameters, the user has to leave $N = 0$ for such parameters. The default case is single values for all parameters, with the values indicated above. The user can click on each button to clear the value in the text widget and enter the desired one. By clicking again on the same button the default numerical value can be recovered.

- **Save** button.
  This button saves the user choices. IMPORTANT: when **Save** button is pressed, no

further modifications are allowed in the physical parameters, so please press it when all your choices in this page are complete. Note also that if the user do not press the **Save** button the default single parameters will be used.

- **Add grid points** button.
  This button opens the **Edit grid** page, by which the user can select further points in addition to the equispaced grid or to the single values. This can be made by entering each additional value and pressing the **Add grid point** button.

- Navigation buttons.
  The buttons **Start page**, **Previous page** and **Next page** allow the user to move backward and forward.

6. OUTPUT OPTIONS

This page is devoted to the choice of the output data on the nuclides whose evolution has to be followed, and the name of the two output files: the first one containing the final values of the nuclide abundances, *parthenope.out*, and the second one containing the evolution of the selected nuclides, *nuclides.out*. In the absence of any user choice, the default set of nuclides stored in *nuclides.out* consists of the first nine, and the default names of the output files are *parthenope_date_time_number.out* and *nuclides_date_time_number.out*, where *_date_time* are the values of date and time corresponding to the run and *number* is the identifying number for a specific choice of parameters.

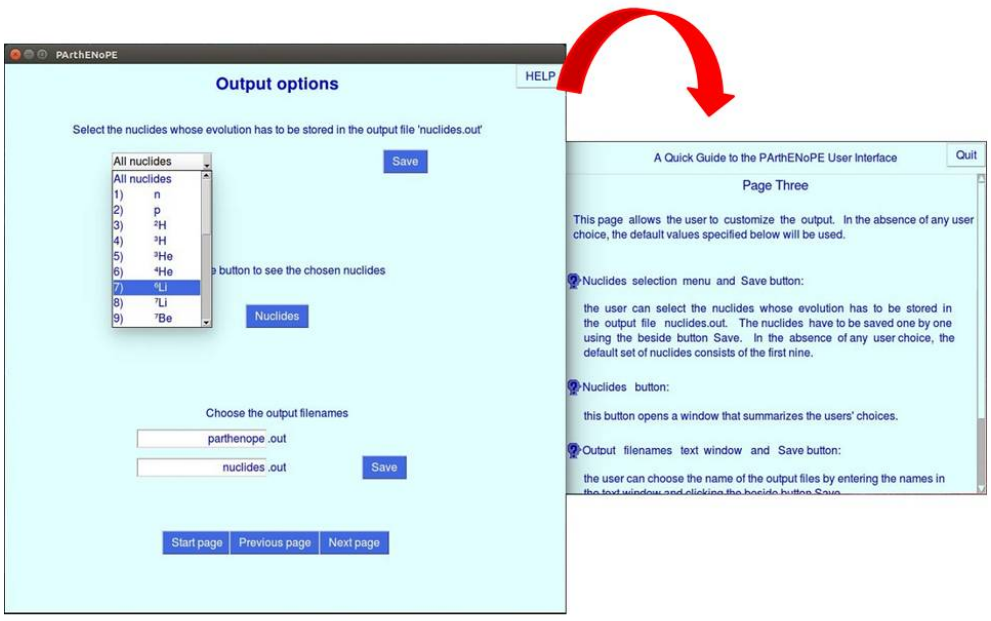

Figure 9: **Output Options** page.

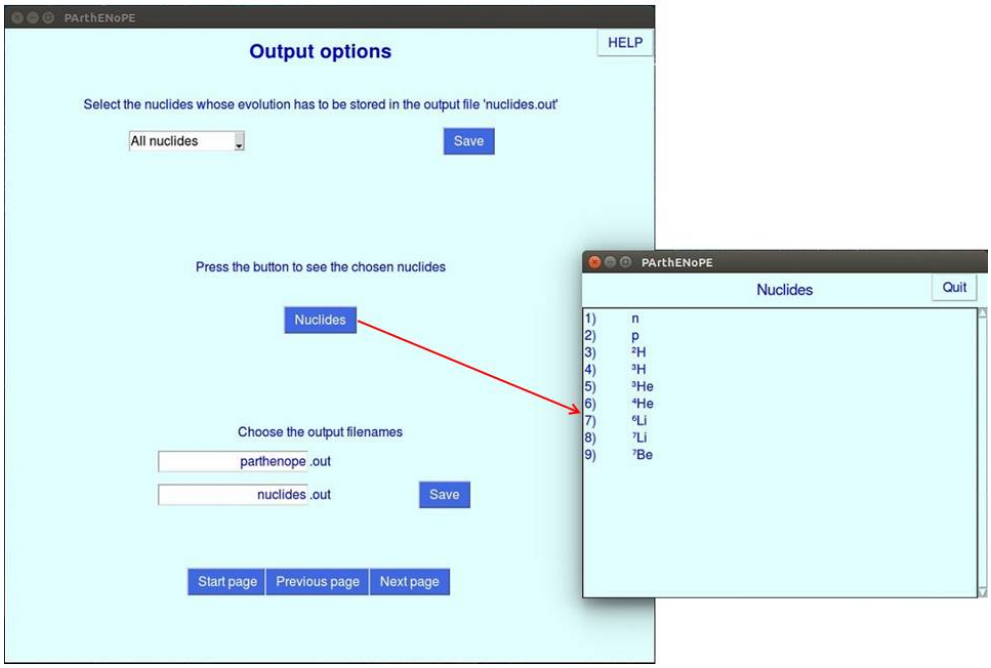

Figure 10: **Output Options** page: nuclides selection.

- **Nuclides** selection menu and **Save** button.
  The user can select the nuclides whose evolution has to be stored in the output file *nuclides.out* from the drop-down list on the top left (see figure). IMPORTANT: note that the nuclides have to be saved one by one using the **Save** button on the top right. The number and type of nuclides that can be chosen depends on the type of network that is currently considered. In the absence of any user choice, the default set of nuclides stored in *nuclides.out* consists of the first nine.

- **Nuclides** button.
  This button opens a window that summarizes the users' selection of nuclides.

- Output filenames.
  The user can change the default names of the output files by entering them in the text windows and clicking the **Save** button. The complete name of the output files will include also the date and an identifying number which connects the output files to the corresponding input files which generates the output. Each input file *input_date_time_number.card* contains the set of parameters corresponding to the given run.

- Navigation buttons.
  The buttons **Start page**, **Previous page** and **Next page** allow the user to move backward and forward.

7. RUN PARTHENOPE

This page allows to launch PArthENoPE with default values of all parameters or with the changes implemented by the user. Depending on the choice of single values or a grid of values of the parameters, the GUI produces one or more configuration files, needed for the PArthENoPE running. In particular:

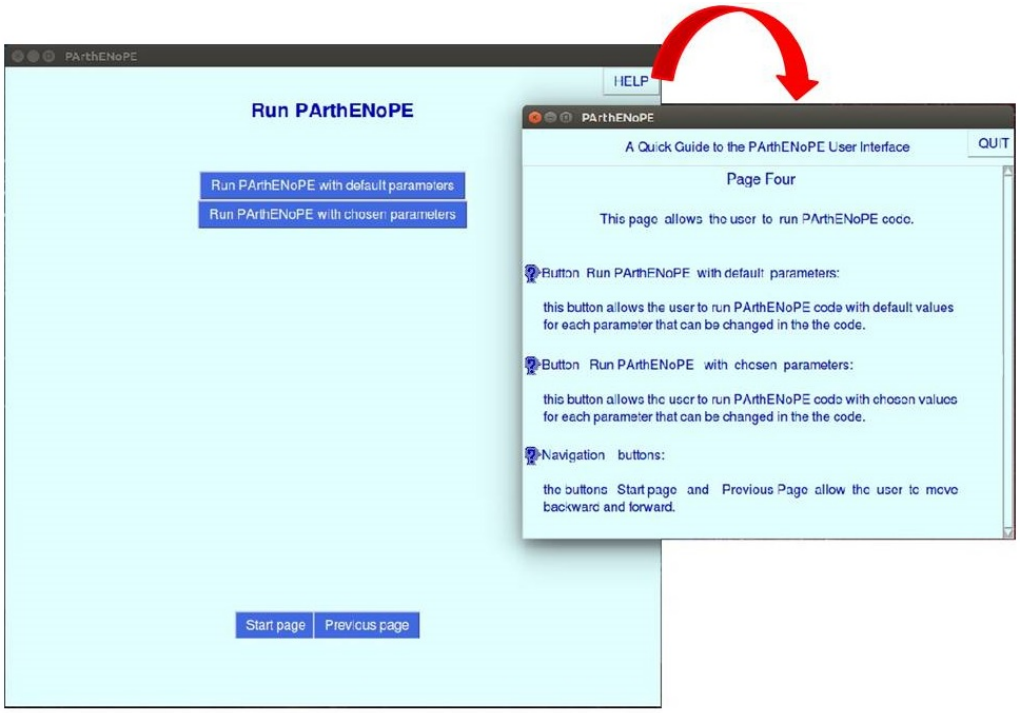

Figure 11: **Run PArthENoPE** page.

- **Run PArthENoPE with default parameters** button.
  This button allows the user to run PArthENoPE with default values for all input parameters.

- **Run PArthENoPE with chosen parameters** button.
  This button allows to run PArthENoPE with the values of the input parameters implemented by the user.

- Navigation buttons.
  The buttons **Start page** and **Previous page** allow the user to move backward before pressing one of the buttons that start the running of the code.

The GUI window cannot be closed until completion of the launching of all the planned runs. The user will find input (*input_date_time_number.card*) and output (*parthenope_date_time_number.out*, *nuclides_ date_time_number.out*) files in a subdirectory of the working directory, whose name contains the values of date and time corresponding to the run. Moreover, in this directory all final values of the primordial abundances can be found in the file *grid_date_time.out*.

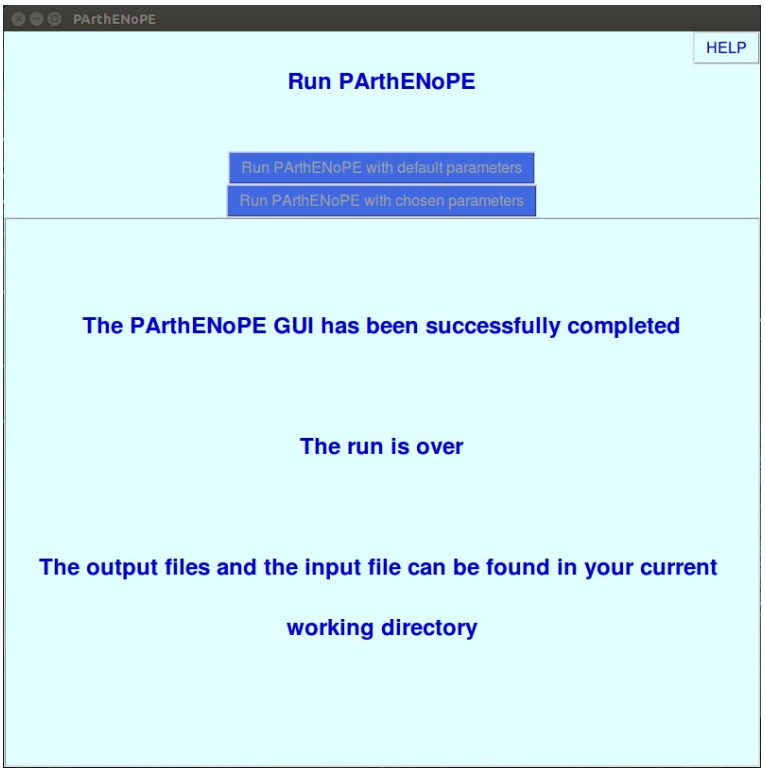

Figure 12: **Run PArthENoPE** page.

BIBLIOGRAPHY

[1] *Fondi della regione Canpania* under "L.R. num. 5/2002 – annualità 2007".

[2] O. Pisanti, A. Cirillo, S. Esposito, F. Iocco, G. Mangano, G. Miele, P. D. Serpico, *PArthENoPE: Public Algorithm Evaluating the Nucleosynthesis of Primordial Elements*, Comp. Phys. Commun. 178:956-971 (2008) [arXiv:0705.0290, astro-ph].

[3] F. Iocco, G. Mangano, G. Miele, O. Pisanti and P.D. Serpico, *Primordial Nucleosynthesis: from precision cosmology to fundamental physics*, Phys. Rept. **472** (2009) 1.

[4] R. Consiglio, P. F. de Salas, G. Mangano, G. Miele, S. Pastor, and O. Pisanti, *PArthENoPE reloaded*, submitted to Comp. Phys. Commun.

[5] P. D. Serpico, S. Esposito, F. Iocco, G. Mangano, G. Miele and O. Pisanti, *Nuclear Reaction Network for Primordial Nucleosynthesis: a detailed analysis of rates, uncertainties and light nuclei yields*, JCAP **0412**, 010 (2004), [astro-ph/0408076].

INDEX

GUI User Manual