

A He I Case-B Recombination Code

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ABSTRACT

Recent calculations of collisionless, Case-B, He I emissivities were performed by Bauman et al. (2005). The source code used in the calculation has been freely available online since that paper was published. A number of changes have been made to simplify the use of the code by third parties. Here I provide details on how to obtain and compile the source, execute the program, and interpret the results.

1. Introduction

This document serves a simple purpose: to inform interested workers about how to obtain and use the “*J*-resolved” computer program discussed in Bauman et al. (2005), hereafter referred to as “the code.” There are no new scientific results presented here, and the methods and predictions of the code are unchanged.

2. Obtaining the Code

The code can be obtained at <http://www.pa.uky.edu/~rporter/j-resolved/>. There are two versions available, but the difference is only in the packaging. The file `heliumRecomb.tar.gz` is convenient for use on Unix and Linux systems, while the file `heliumRecomb.zip` is more convenient for Windows machines.

3. Compiling the Code

While I have tested the code on several systems, I cannot guarantee that it will compile correctly on any given system. Nonetheless, the code will likely work on any version of

Microsoft Windows, Unix, Linux, or BSD. We have made no attempt to compile the code in MacOS.

Before compiling, you may wish to edit the file Helium.h so that the variable OUTPUT_DIR on the first line points to a directory other than where the source files are located. Now you are ready to compile. The preferred compiler is the open-source GNU compiler, gcc (available at <http://gcc.gnu.org/>). Compile with gcc using the following commands:

```
gcc -c *.c
gcc -o EXECUTABLE *.o -lm
```

where EXECUTABLE is whatever filename you wish to give to your executable (i.e., `helium.exe`).

The code has also been successfully compiled in Microsoft Visual Studio. In Visual Studio, create a new project from the file/new project option. In “Project Types” select “Visual C++ Projects.” Under “templates” select “Win32 Project” and enter a name for the project (the name of the executable will be the project name with “.exe” appended). Click OK. Next the Win32 Application Wizard opens. Click “application settings.” Select “console application” and “empty project” then click on “finish.” Now add all the source and header files to the project with the “project/add existing files” option. The debug and optimized versions are referred to as “debug” and “release”. Compile the source with the “build” commands in the “Build” menu.

4. Executing the Code

If there were no errors in the previous step, you should now have a working executable. Next, simply type the executable filename at the command prompt in the directory where your executable was created. Note that some systems will not automatically look for the executable in the current directory. In this case, the command would be “./helium.exe”. The code should respond by printing the following output and then exiting:

```
USAGE: executable nmax Te toppoff ST-mixing JobName
executable - the executable filename
nmax       - the highest principal quantum number to explicitly consider
Te         - the electron temperature in Kelvin
toppoff    - switch that enables (1) or disables (0) recombination above nmax
```

ST-mixing - switch that enables (1) or disables (0) singlet-triplet mixing
JobName - a name for this calculation, will also appear in output filenames

Each of the six items after **USAGE:** must be specified and they must be specified in this exact order. The minimum **nmax** is 15. The maximum is unknown. The code will almost certainly fail at some **nmax** but has been successfully run with **nmax** as high as 100. (See Bauman et al. [2005] for a discussion of convergence with respect to **nmax**.) If singlet-triplet mixing is disabled, the results will be for the pure *LS*-coupling case. Finally, **JobName** is any name you wish to give to the job and will automatically be included in the filenames of the output. Here is an example:

```
./helium.exe 15 10000 1 1 testrun
```

This example will produce results for **nmax**=15 at a temperature of 10,000 K, with **topoff** and **ST-mixing** included. The name “testrun” will be assigned to the job.

5. Interpreting the Results

The above example will produce the following output files:

```
testrun_15_Output.txt  
testrun_15_Results.txt  
testrun_15_Results_Ryan.txt  
testrun_15_Levels_st.txt  
testrun_15_Thrshld_X_Scts.txt  
testrun_15_Solution_st.txt  
testrun_15_Vector_st.txt  
testrun_15_OscStrMethod_st.txt
```

The first two parts of each output filename are given by the **JobName** and **nmax** parameters. The last part of the filename (before the “.txt”) describes the file contents as shown in Table 1.

6. Referencing Use of the Code

The proper reference for use of the code is to the Bauman et al. (2005) paper. For reproducibility, the input parameters should also be reported. Workers may also wish to

reference this manuscript and/or include a link to the source website.

7. Acknowledgments

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REFERENCES

- Bauman, R. P., Porter, R. L., Ferland, G. J., & MacAdam, K. B. 2005, ApJ, 628, 541
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Table 1. Output filenames and contents.

Last Part of Filename	Contents of File
Output	Basic sanity checks and various data; this file can be quite cryptic.
Results	<i>J</i> -resolved wavelengths, emissivities, oscillator strengths, transition probabilities, occupation numbers, etc.
Results_Ryan	Same as Results but <i>nLS</i> -resolved for comparison with the He I model in Cloudy (see Porter et al. 2005, 2007).
Levels_st	Various information about levels. The “st” in the filename will be “ls” if <code>ST-mixing</code> is disabled.
Thrshld_X_Scts	Threshold photoionization cross-sections from various sources.
Solution_st	The solved vector of level populations (in atomic units).
Vector_st	The initial vector of recombination rates (in atomic units).
OscStrMethod_st	The sources of oscillator strengths for each transition.