Astro 376: Python Assignment 1
Using Conditional Array Operations on Large Catalogs

(Assigned on Th Apr 1, 2021. Due by 11.59 pm CT on Th. April 8, 2021.)

Overview of Assignment

- In this homework, you will be applying what you have learnt in the Python tutorial over the last week. For some questions, you will need to go beyond the Python tutorial and consult online help. We also assume that by now, you are comfortable with basic Mac OSX/Linux commands and some text editor of your choice (like Aquamacs or Vi). Recall that you can let Terminal choose a text editor for you if you type '`open file`'. If you need a refresher please consult the Mac OSX/Linux tutorial that you practiced in class earlier. The number of points for each question is indicated in brackets, and the total score is 100 points.
- Your main task is to write a Python program, which does the following:
  - Reads a very large formatted catalog containing properties of galaxies (e.g., their redshifts, stellar masses, and rates of star formation) out to early epochs *when the Universe was less than half of its present age.* These properties were derived using some of the most cutting-edge surveys of galaxies conducted with NASA's *Hubble Space Telescope* and Spitzer Space Telescope, as well as ground-based observations at many different wavelengths.
  - Uses conditional operations on array indices to extract elements that satisfy specific criteria (e.g., specific redshift ranges, masses, etc).
  - Performs specific operations on these elements and writes a formatted output catalog.

Detailed Instructions

(a) Create a sub-directory called 'hwk3' in your python directory and change (cd) to this directory. Retrieve the file *'hwk3-catalog.txt'* by typing in a **single** line

```
curl -u cosmos:ast376web www.as.utexas.edu/~sj/a376-sp21/secure/hwk3/
hwk3-catalog.txt -o hkw3-catalog.txt
```

(b) Put all the files that you create for this homework into the sub-directory '~/python/hwk3'. *Your grade will be based on the homework that you hand in, as well as any electronic files you might be asked to produce in this directory.*

(c) Please write a single Python program to do all the questions in this homework and put in *short comments within the program to indicate which part of the code addresses which question.* For instance, the comments might read 'Code for question 1', 'Code for question 2', etc. *Please name your Python program 'hwk3-myname.py", where 'myname' is your name (e.g., hwk3-jogee-shardha.py.)* Your code should be a Python script (.py file) that can be run from your hwk3 directory. Make sure all relevant files are also in your hwk3 directory when you run your code and when you submit it. **Please submit your Python file with your name on it on Canvas. Please also submit a printout of the answers and of the output catalog requested in questions 1 to 5.**

Note that you can write the printout from a Python script (i.e., whatever is output by the print() command) if you execute your script as:

```
python hwk3_myname.py > output.txt
```

(d) **For full credit, you must use the correct way to program in Python.** Getting to the right answer using a bad method will only get you partial credit. Note that copying the programs of your fellow students is considered as **cheating** and will lead to a "Fail" grade for both the person who copies the program and the person who allow their program to be copied.

1. The catalog 'hwk3-catalog.txt' has information on a subset of galaxies, which have been observed with the optical Advanced Camera for Surveys (ACS) on the *Hubble Space Telescope* and the mid-infrared MIPS instrument at a wavelength of 24 microns aboard the *Spitzer Space Telescope*. In addition, observations from ground-based telescopes from the ultra-violet (UV) to near-infrared (NIR) have also been taken. Read through the header information in the catalog to understand the different quantities that have been recorded for each galaxy.

   Read in the file 'hwk3-catalog.txt' using the methods you learned in the Python tutorial. You will need to specify the correct format since this is a complicated file. Note that commented lines will be ignored by Python. How many galaxies did you successfully read in? [**25 points**]

   Hint: To read in this catalog, use np.genfromtxt() which can handle strings, integers, and float variable types, instead np.loadtxt(). The usage for both is very similar. You will need to read in the string, float, and integer variables separately as np.genfromtxt() cannot read different variable types at the same time (i.e., you will load each variable type on a different line with np.genfromtxt()). See the posted Part_2.ipynb solutions for an example of how to read in different data types and call different columns.

2. Select all the galaxies that have photometric redshifts in the range $0.55 < z < 0.60$. How many galaxies are in this range? [**15 points**].

3. Of the galaxies you selected with redshifts $0.55 < z < 0.60$, how many of these have a stellar mass $M_* > 10^{10}\,M_\odot$? [**15 points**]

4. This catalog contains galaxies observed with the *Hubble Space Telescope* in the UV and optical. It is often useful to know which galaxies have been observed in other wavelengths. This catalog contains a column "WHMIPS" that specifies whether or not a galaxy has been observed in the mid-infrared with the *Spitzer Space Telescope*. In a future assignment, you will need to remove galaxies that do not have this measurement so that you can continue with your analysis. Remove the galaxies from your answer to (3) that do not have a detection with *Spitzer* at 24 μm. How many galaxies remain? [**15 points**]

5. Your sample of galaxies now contains all the galaxies for which chere is a *Spitzer* detection at 24μm within the redshift range $0.55 < z < 0.60$ that have stellar masses $M_* > 10^{10}\,M_\odot$. Now you will save the contents of this sample to an output catalog. called "lastname-sample.txt", where "lastname" is your last name. For each galaxy, save the galaxy name (column 3 of hwk3-catalog.txt), the stellar mass, the photometric redshift, and the value for

"whmips". Your saved output catalog should look like a table where each row is a galaxy and each column is a different attribute. Turn in your output file. [**30 points**]

Hint: For this problem, you should save all the variables as strings (see Part_2.ipynb solutions for how to save different data types). The np.savetxt() function has trouble reading a combination of strings, floats, and integers so instead we can save all arrays as strings to get around this (note that you can then read that same data in as integers or floats when you read the saved output file in Python with np.loadtxt or np.genfromtxt).

END OF ASSIGNMENT