Fundamentals of Computing for Researchers (FCSR)

Final Student Project Showcase
Bush Digital Telescope

FCSR - Fundamentals of Computing for Researchers - an experiential course

Welcome!

We are Freshmen, Juniors, Seniors, and the very “senior” faculty

Anne, Armaan, Anya, Avie, Carter, Erik, Heidi, Luke, Madden, Philipp, Chandru

We learned about Jupyter Notebooks for digital research, Python Programming and use of Raspberry PI as a research tool

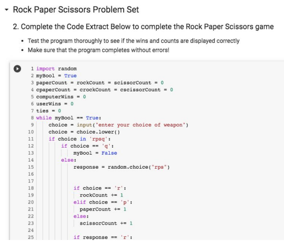
We studied basic Python Programming tasks and completed 2 projects

PLEASE HOLD YOUR QUESTIONS UNTIL THE END OF THIS PRESENTATION

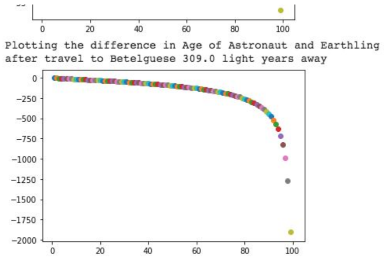
What are Jupyter Notebooks?

Madden's
8-Ball game

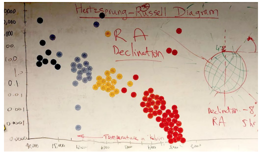
1. The 21st century digital and dynamic research notebook, computing environment, and publishing engine all rolled into one!
2. Browser-based from client laptop - no local software installation needed
3. Used by Berkeley Institute of Data Science - also used at Bush Math and CS depts
4. Almost anything related to Data Science and Python based research are published in Jupyter notebooks today
5. We used it every day in our class as our computing environment
6. We used it in our projects as a publishing tool
7. You will see examples throughout our presentation



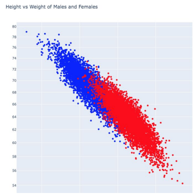
Heidi's RPS

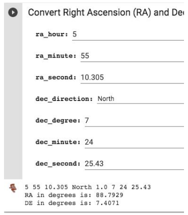


Luke's Space Travel

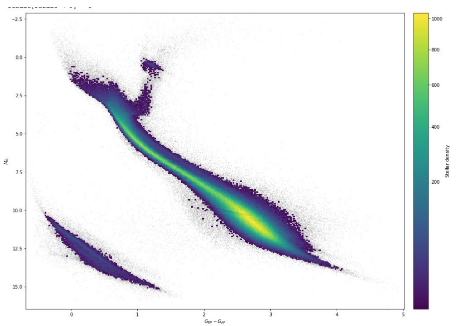


A synopsis of the first FCSR project - Lives of Stars - Scale of the Universe





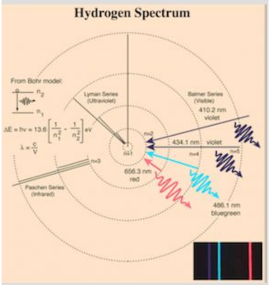
1. Studied the lifecycle of a star using the Hertzsprung Russell Diagram (HRD)
2. Learned to handle large datasets from robotic astronomical satellites
3. Clean and analyze datasets as individual and connected series (columns)
4. Created celestial coordinate converters with user interactivity
5. Static and dynamic (interactive) plotting of related dataset points
6. Studies locations of hot (blue) and cool (red) stars on the HRD
7. Published results in a dynamic Jupyter Notebook
8. Anya’s interactive Height-vs-Weight Jupyter notebook
9. Example of Erik’s Right-Ascension Declination converter
10. Team Project plot of 1M stars with 200 parsecs of our Sun

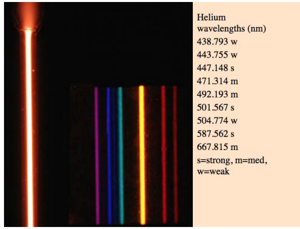


Bush Digital Spectroscope Project Objectives

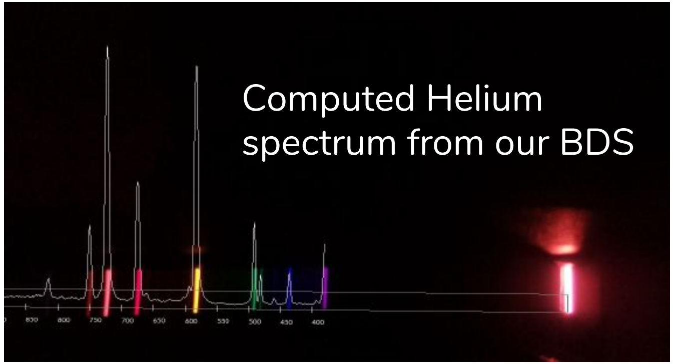
1. Apply computing technologies learned to a hands-on project
    a. Jupyter Notebooks
    b. Python programming language
    c. Raspberry Pi “pocket” computer (RPI)
2. Build a scientific instrument (BDS) and automate it using RPI & Python code
3. Create, collect and analyze scientific data for research (emission wavelength spectra)
4. Present Live BDS results to Faculty and Peers using the created Jupyter Notebook
5. Contribute BDS and operating instructions to Bob Huffman and his Astronomy classroom

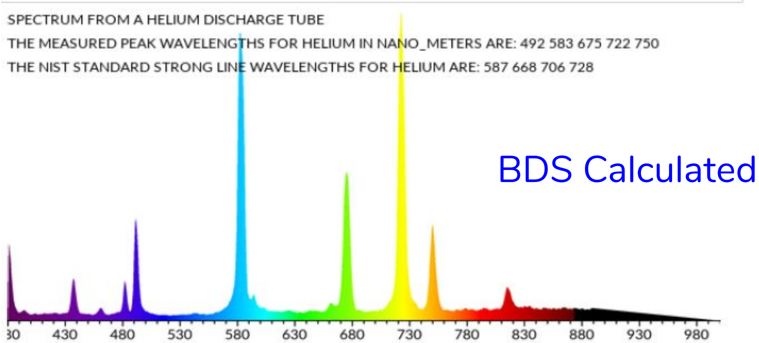
What causes an emission spectrum?





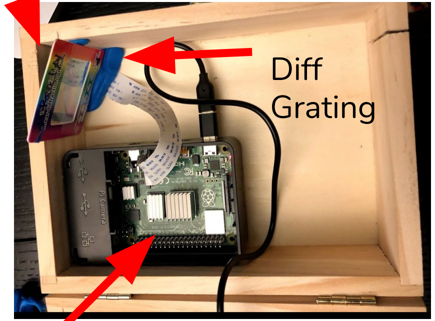
1. Atoms of a gas are heated to high temperatures in the middle of stars ot in a discharge tube
2. This causes the electrons to get excited (energized) and jump to an outer orbital
3. It then quickly falls back to its original inner orbital releasing photons of a specific frequency/wavelength or a specific color (VIBGYOR)
4. The bigger the jump the more energy released (higher freq, smaller wl). Some of these freq are in the visible range called the Balmer spectrum
5. Light from the sun (or discharge tubes) emit these light of specific freq (colored spectral lines) which can be seen when diffracted by a prism or diffraction grating





BDS Calculated Peaks!

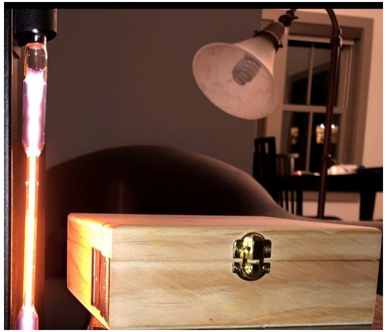
Building the Digital Spectroscope



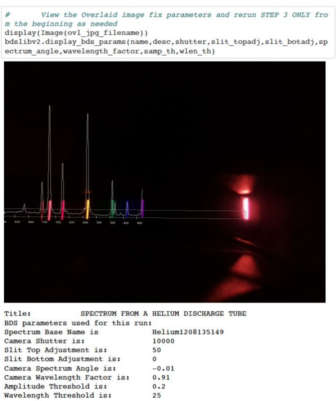
Five teams of 2 students each built a Spectroscope
One is being passed around for you to look at
It is actually functioning as you are looking at it!

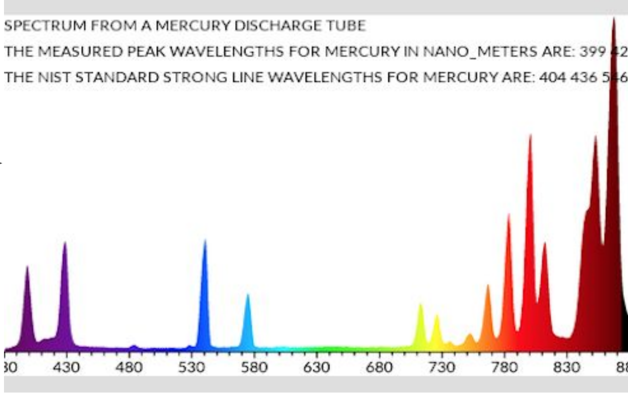
When enclosed it provides a perfectly dark environment for spectral images

Communicating with the RPI



100% wireless!





Discharge Tube, Daylight, a Cuvette, or other sources of light emitted from the source being analyzed on BDS running Jupyter Server

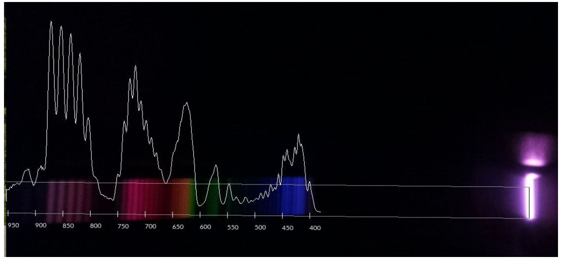
BDS Jupyter Notebook accessed via remote laptop

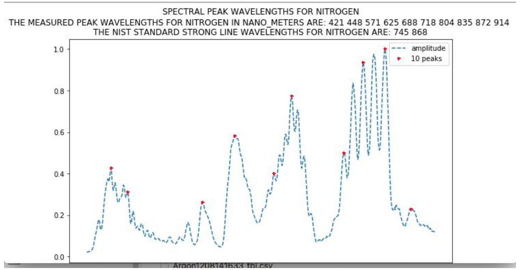
Spectrum and Peak Wavelengths computed using Python code running on the BDS

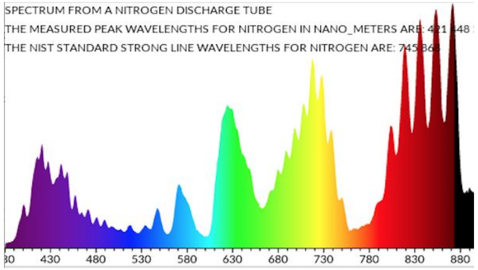
Results delivered remotely to the laptop Browser. This is the spectrum of Mercury

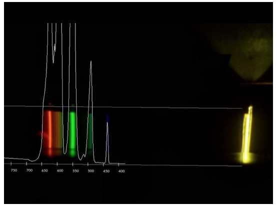
Live Walkthrough of Python Code in the BDS via Jupyter Notebook

1. Obtain Raw Image of Spectrum
2. Create Pixel Array of Raw Image (R G B intensities for each pixel)
3. Locate the slit in the Pixel Image (brightest vertical line about 3/5ths down to the right
   a. (this is where the Python is looking for the slit)
4. Draw an aperture to contain spectrum (a rectangular area of analysis)
5. Compute the Wavelength Peaks where the maximum brightness occured (spectral lines) within the aperture box
6. Compare with the standard for the element under analysis

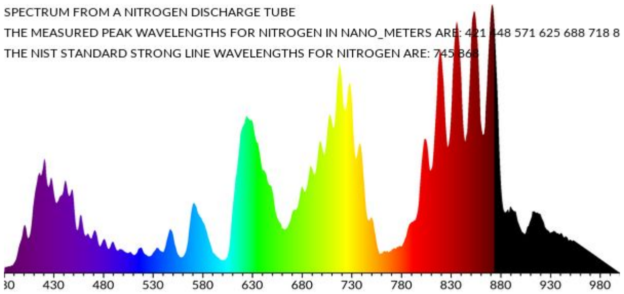






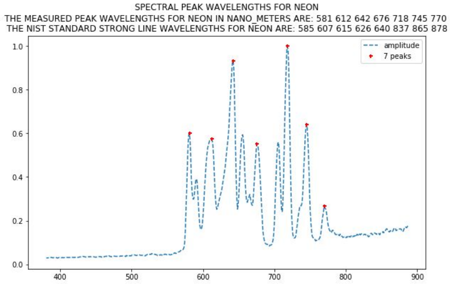


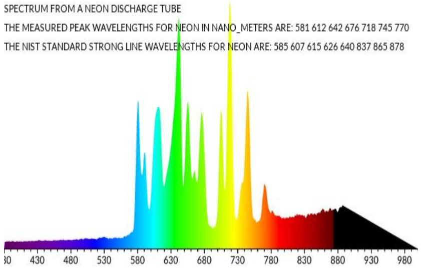
Live Runs of BDS

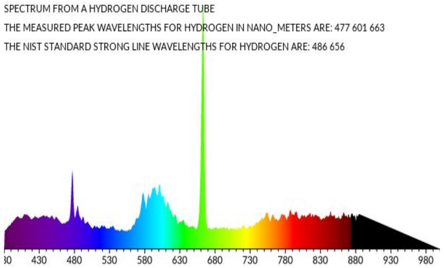


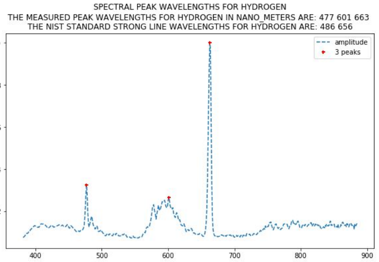
1. Daylight Spectrum accessed via Avie/Armaan team BDS
2. Compact Fluorescent Lamp Spectrum obtained via Anya/Madden team BDS
3. Bright LED spectrum obtained via Erik/Philipp team BDS
4. Helium Discharge Tube Spectrum obtained via Luke/Heidi BDS
5. Mercury Discharge Tube Spectrum obtained via Anne/Carter BDS

We will do this simultaneously as we are connected to all 5 BDS remotely via a single laptop!









Results and Feedback

1. Thanks for listening
2. Contribution of BDS to Bob Huffman's Physics and other science classrooms
3. Do you believe that we met BDS and course objectives?
4. QUESTIONS ??