Practical No :- 02
Spectroscopic Analysis of Quasar Absorption Lines

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1 Introduction

Spectral cubes contain information about the spatial extent and brightness of a celestial object, with wavelength/velocity acting as the third axis of the cube. These data cube files are stored in the astronomical-standard FITS format. This exercise utilizes the HI 21 cm line emission data from the HI4PI survey (HI4PI Collaboration 2016). This transition occurs due to the flipping of the electron spin in a hydrogen atom, emitting 21 cm radiation primarily from cool gas in the Galaxy and elsewhere in the Universe.

2 Moment Maps

Moments help extract spectroscopic details from the data cube. For example, the 0th moment yields the integrated intensity over a spectral line (unit: K km s^{-1}). The 1st and 2nd moments provide insight into the intensity-weighted velocity of the spectral line (unit: km s^{-1}) and its velocity dispersion (unit: km^2 s^{-2}) respectively. Mathematically, these are obtained through the following integrals:

$$M_0 = \int I_\nu d\nu \tag{1}$$

$$M_1 = \frac{\int \nu I_\nu d\nu}{\int I_\nu d\nu} \tag{2}$$

$$M_N = \frac{\int I_\nu (\nu - M_1)^N d\nu}{\int I_\nu d\nu} \tag{3}$$

3 Practical Exercise

3.1 Data Acquisition

The FITS file used in this exercise was downloaded from `http://cdsarc.u-strasbg.fr/vizier/ftp/cats/J/A+A/594/A116/CUBES/GAL/TAN/TAN_C14.fits`.

3.2 Data Exploration and Slicing

Using the `SpectralCube` package, the FITS file was read and explored. The `quicklook()` method was used to slice through the data cube in different ways.

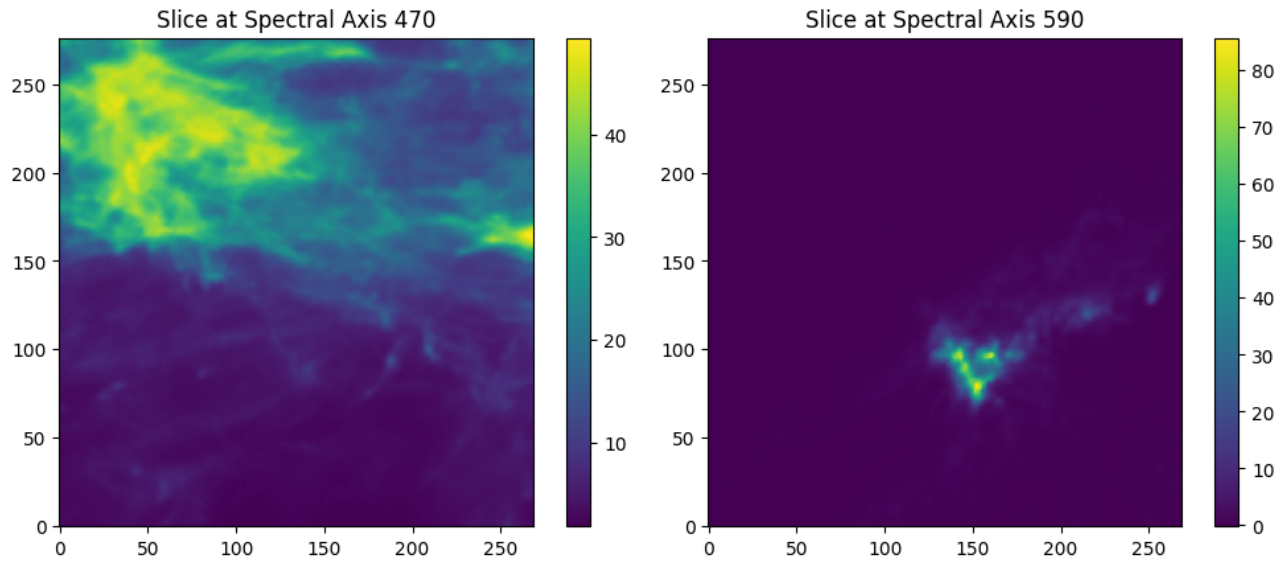

Figure 1: Slices of the data cube.

Spectral lines observed for different slices

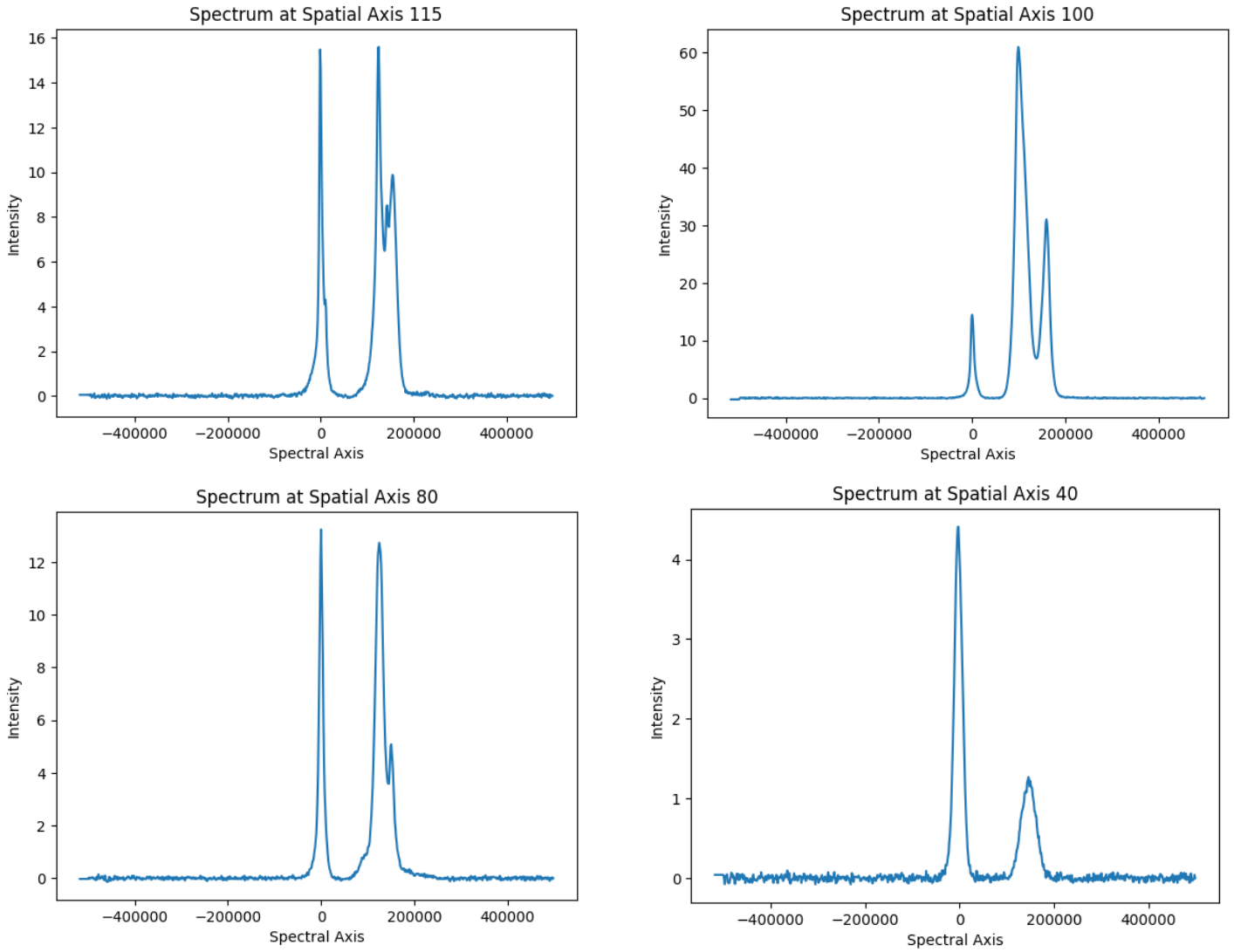

Figure 2: Extracted spectra from different regions of the data cube.

3.3 Subcube and Spectral Slab Extraction

Using the `world()` method followed by `subcube()` and `spectral_slab()`, a small part of the entire data cube was cut out.

3.4 Moment Calculation

The 0th and 1st moments were computed using the `moment()` commands. The World Coordinate System (WCS) was used to display the moment maps.

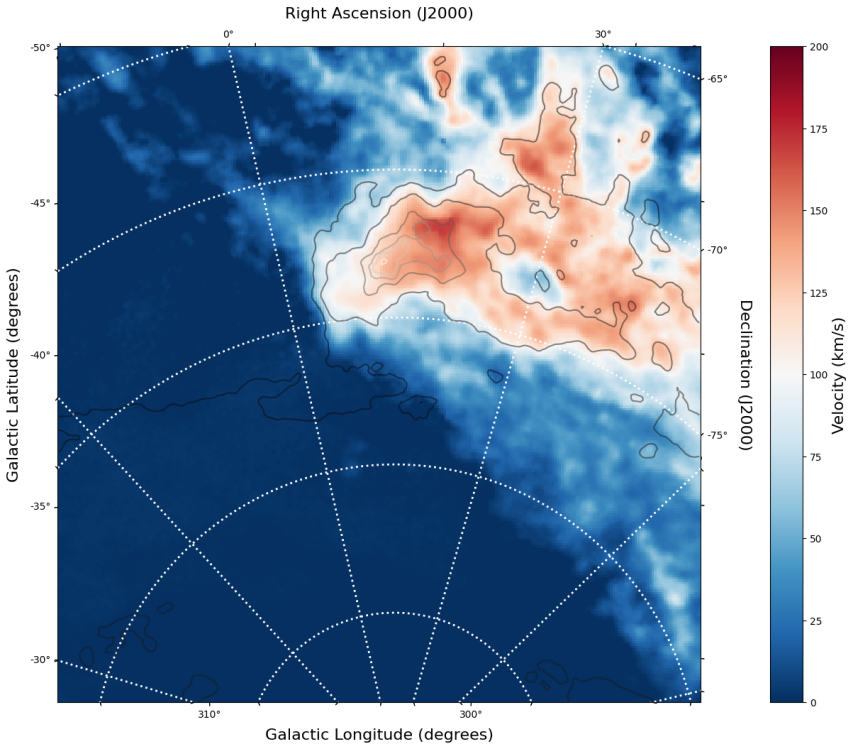

Figure 3: Moment map of the data cube.

4 Conclusion

This exercise demonstrates the use of moment maps to extract valuable spectroscopic information from a spectral cube. The HI 21 cm line emission data from the HI4PI survey provided insights into the spatial and velocity distribution of hydrogen gas.

5 References

- `https://spectral-cube.readthedocs.io/en/latest/moments.html`
- `https://notebook.community/adrn/tutorials/notebooks/FITS-cubes/FITS-cubes`
- `https://ui.adsabs.harvard.edu/abs/2016A&A...594A.116H/abstract`