Testing CHART in Quadrant I From Gilbert and Tempe Arizona

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Introduction:

Two data sets were taken at relatively the same time of year in two different locations, -111.915970 N 33.418944 W Tempe, and -111.801682 N 33.360355 W Gilbert, with the intention of comparing results from similar parts of the sky in different locations with varying degrees of noise interference. It was predicted that Tempe has a greater amount of noise interference due to a higher population and a more industrial environment than Gilbert, although both data sets include some noise or unexpected skew in measurements.

Setup:

Both data sets were taken using the full sized, cardboard horn and the v3 dongle RTL-SDR. The Gilbert data was taken with the Raspberry Pi 400 and the Tempe data was taken with the Raspberry Pi 4 model. Both Pi's had the CHART disk image installed.

For the Tempe data, four pointings were taken spanning from the galactic center to the edge in Quadrant I of the Milky Way with the standard apparatus. The first trial's data was lost but the last three pointings were used to test the new analysis procedure. The standard setup was used with the pi connected to a monitor, keyboard, and mouse (as opposed to using SSH) and data was taken from a roof patio just east of ASU in a very populated area with many potential noise signals.

7 integrations at 10 seconds each were taken between 1417 to 1423 MHz between 11:30 and midnight of June 18, 2024. Coordinates were measured using the Stellarium app; the phone was pressed to the bottom of the CHART horn to ensure an accurate pointing and a screenshot was taken for analysis later.

For the Gilbert data, three pointings were taken of the galactic center in Quadrant I of the Milky Way. 5 integrations at 10 seconds each were taken between 1414 and 1424 MHz on June 26, 2024 from 11:30 to midnight. Data was also taken using the standard pi-monitor set up, and Stellarium was used to track coordinates for analysis. This time, data was taken in a relatively less populated area with less potential for interference.

Galactic and Celestial Coordinates:

Tempe:

- **Pointing 1:**
  - l= 40.18° b=-9.75°
  - Az: 120°   Alt: 40°
- **Pointing 2:**
  - l= 63.92° b=-4.53°
  - Az: 90°   Alt: 50°
- **Pointing 3:**
  - l= 82.61° b= 1.35°
  - Az: 60°   Alt: 50°

Gilbert:

- **Pointing 1:**
  - l= 85.73° b= -0.83°
  - Az: 58°   Alt: 56°
- **Pointing 2:**
  - l= 55.69° b= 0.52°
  - Az: 115°   Alt: 65°
- **Pointing 3:**
  - l= 4.80°   b= -3.21°
  - Az: 174°   Alt: 30°

Results/Data:

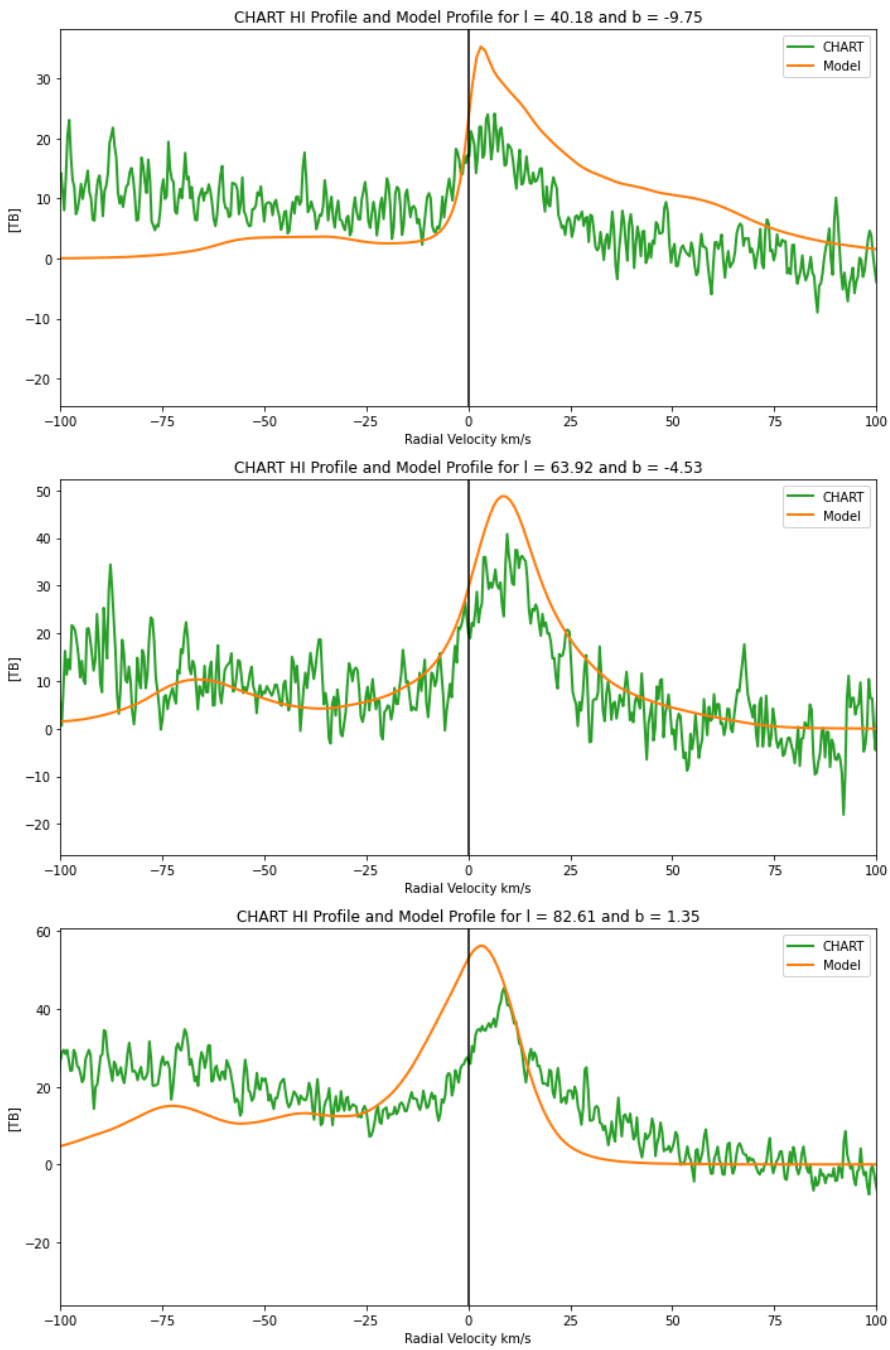

Figure 1: *Tempe Data Velocity Curves*:
The above graphs display the three rotation velocities measured in Tempe (green) in comparison with the expected rotation curve (orange) with the galactic coordinates listed in the title. The first two trials show the data in line with the expected plots from the first two galactic coordinates, however the third plot shows a discrepancy in the measured and expected peaks. This could be caused by obstruction of the data collection by a building or other noise sources or could be caused by misreading coordinates.

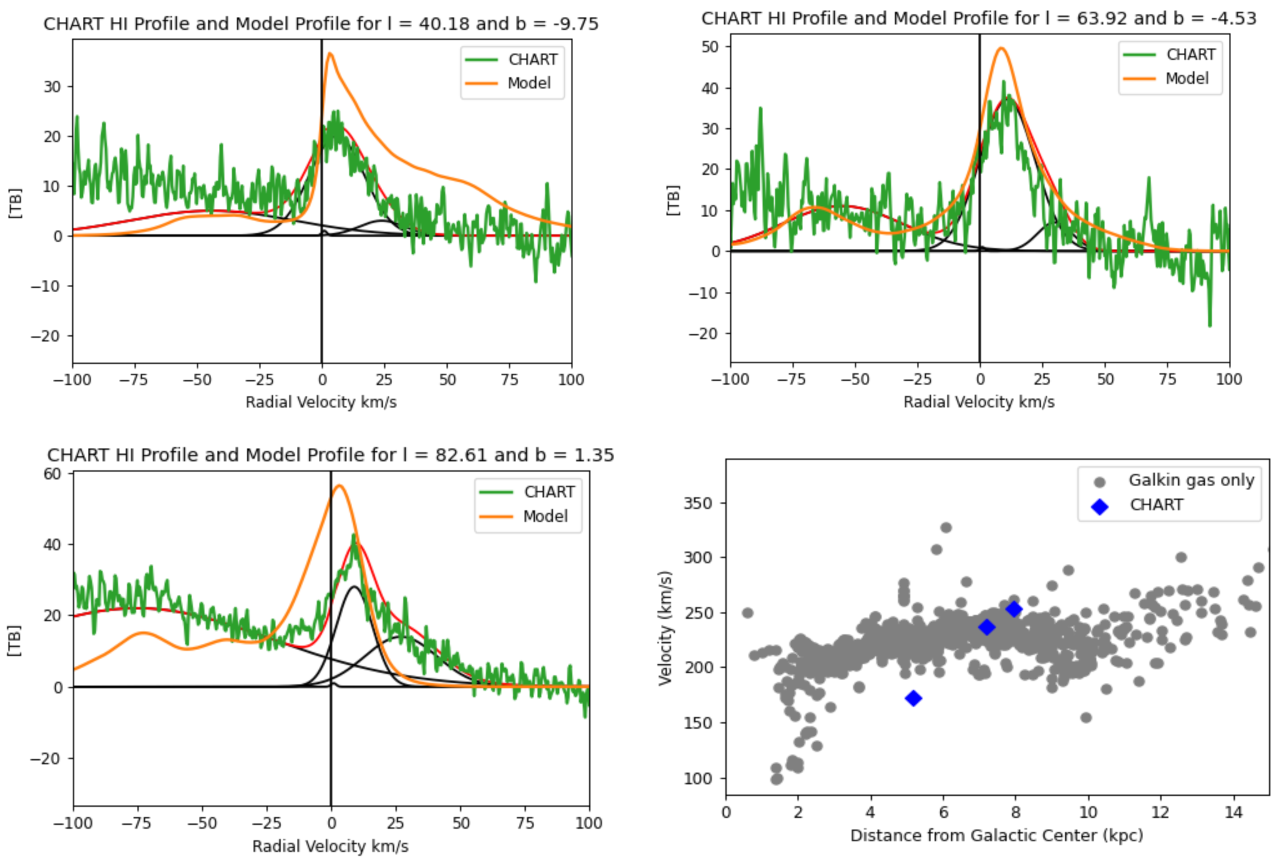

Figure 2: *Gaussian Fits and Rotation Curve Tempe:*

Above are the applied Gaussian fits for each Tempe trial, upper left being trial 1, upper right as trial 2, and lower left as trial 3. These fits were then used to find particular coefficients and velocities, which were then entered following the analysis tutorial to formulate a rotation curve. The lower right plot shows Tempe velocities at their respective distances from the galactic center in blue in comparison to the Galkin Gas data in gray. The second two trials fall well inside the Galkin data while the first data point falls much lower, which is interesting since trial 3 was the one that least matched the expected data. However, in the context of the collection location, this makes sense and is likely caused by data obstruction since the data was taken so low on the horizon.

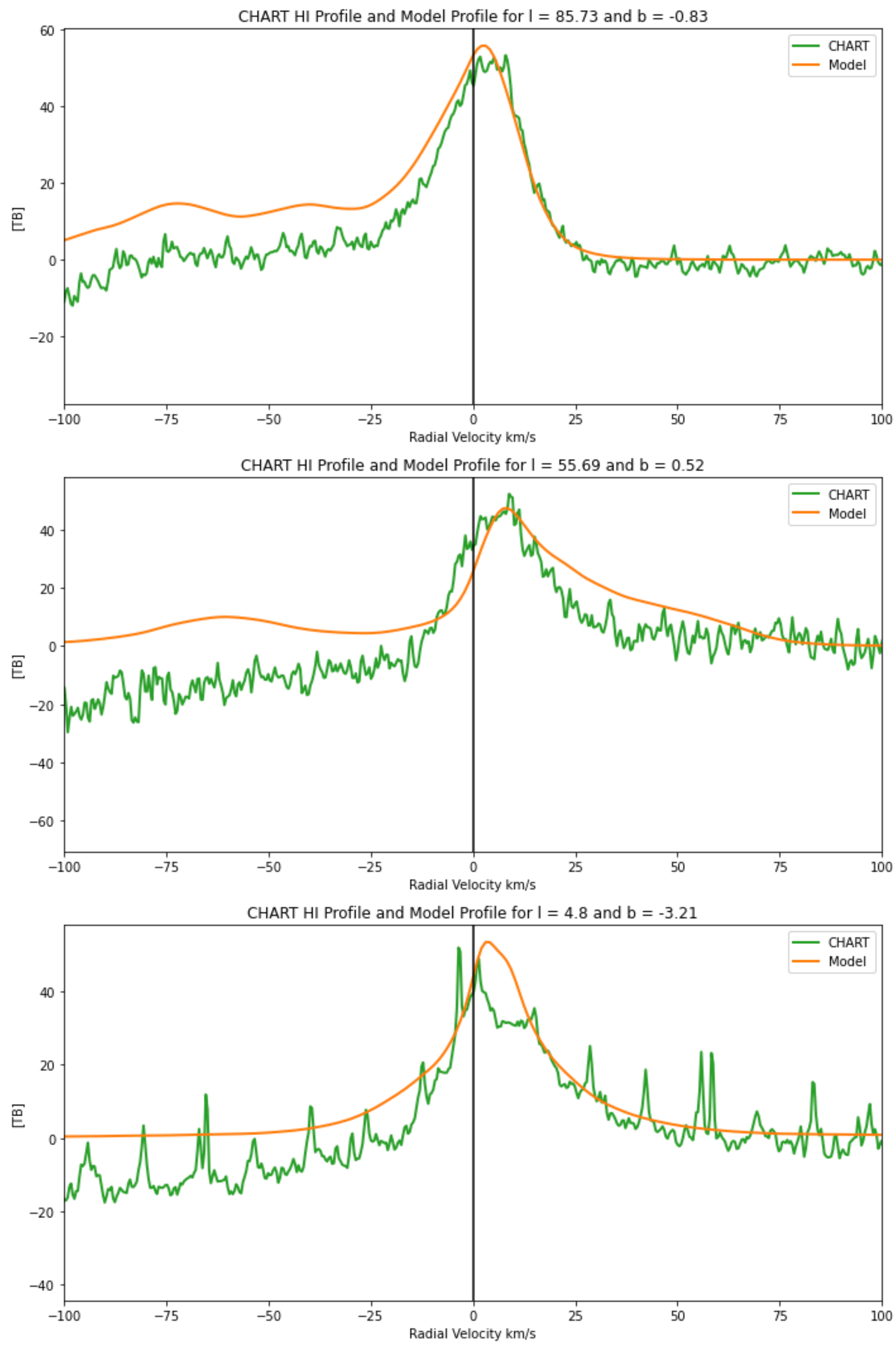

Figure 3: *Gilbert Data Velocity Curves:* The above graphs display three rotation velocities measured in Gilbert (green) in comparison with the expected rotation curve (orange) of the galactic coordinates listed for this location. The data aligns relatively well in the first two trials, yet shows a slight discrepancy in the third run, with some very clear spikes of interference.

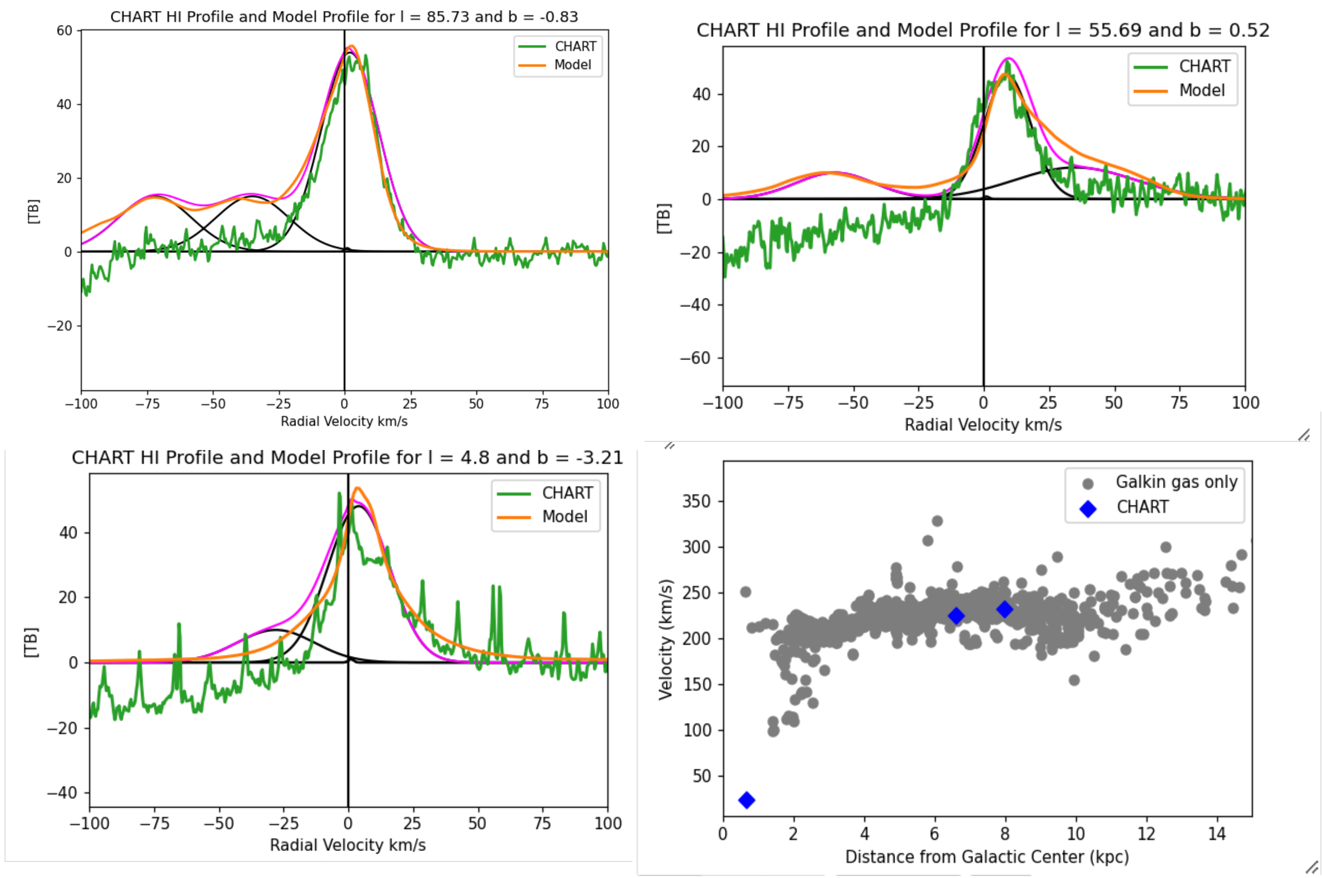

Figure 5: *Gaussian Fits and Gilbert Rotation Curve:*
Above are the applied Gaussian fits for each Gilbert trial, with the top left graph being Trial 1, the top right graph being Trial 2, and the bottom left being Trial 3. These fits were then used to find particular coefficients and velocities, which were then entered following the analysis tutorial to formulate a rotation curve. After entering the highest velocities, the above rotation curve was generated on the bottom right. The first two data points fall well within the Galkin gas set, with the third point falling very low on the curve. Though there is no Galkin data recorded that low, this third data set follows typical predictions and trends at these closer distances.

Analysis/Conclusions:

When comparing the two sets of data, Gilbert and Tempe match relatively well amongst each other. Obstructions in the Tempe data include possible noise or other signals from the city in the first trial as the data was taken very low to the ground. This could be powerlines, radios, etc. Other possible obstruction could include a possible building obstruction in trial three. The horn was pointed very close to the edge of a roof, which may cause interference and the misalignment between expected and recorded data. In Gilbert, interference was primarily seen in the third trial and is also thought to be the result of household appliances and other radio interference.

Common errors included attaching the LNA backwards, incorrectly installing the operating system without use of the CHART disk, failing to turn on Bias T, and overheating the system. To combat these issues, install the CHART disk when setting up the Raspberry Pi Imager. Instead of selecting a standard operating system, select a custom .img and use the CHART disk. The CHART GUI will automatically appear on the desktop and the operating system will install from here as well. For the LNA, ensure the "input" side of the LNA is connected to the telescope, with the "output" connected to SDR. A bright white light should turn on during data collection; if the light is not on, check that it is attached the correct way or damaged. Then, when running your GUI, ensure that the Bias-T switch is turned on in the GUI. Double check the LNA is working by watching for a light once the data collecting begins. To combat overheating, first make sure your pi has an ample power supply— if it doesn't you will see a low voltage warning. Having a piece of metal to conduct also helps avoid overheating, such as a metal box or plate.