Determining Properties of HI Emission Regions in the Interstellar Medium

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Properties of Stellar Forming Regions

Stars form in cold, dense clouds in the interstellar medium (ISM) of our galaxy and other galaxies in the universe. The formation of these clouds from warmer ambient gas is not well understood. Radio telescope maps of potential star-forming regions should show a warm outer layer around a cool dense center.

Reasons for Spectral Fitting Program

We wish to study the properties of an ISM region recently mapped in hydrogen 21cm-line emission with the Arecibo radio telescope. The shape of the spectral line is affected by the line opacity and other parameters, so in principle, cold regions should be identifiable by fitting the line shapes.

Building Chi Squared Space

The fitted line shape is described by the following equations:

$$\sigma_{line} = \frac{FWHM}{8\sqrt{8\ln 2}} \qquad \tau = \tau_0 e^{-\frac{1}{2}(\frac{v-v_0}{\sigma_{line}})^2} \qquad T_b = T_s(1-e^{-\tau}) + T_{bg}e^{-\tau}$$

where the highlighted parameters are the free parameters that define a four dimensional space. Chi squared vales in this space were explored with the Nelder-Mead 'amoeba' method in our code to find the parameters that provided the best fit.

Results of Fitting Program

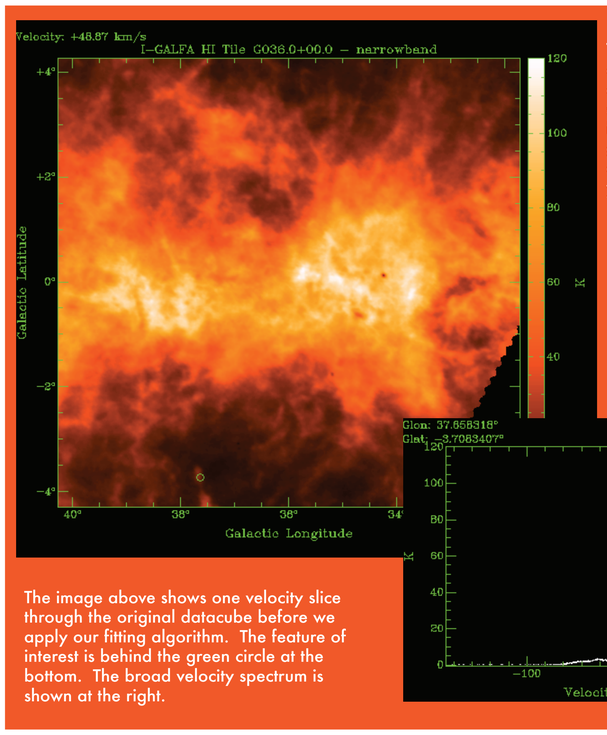
The method succeeded in mapping gas velocity, line width, temperature, and optical depth throughout the cloud with reasonable coherence. From these parameters, column density, mass, and turbulent Mach number can also be derived. The target cloud shows a warm, transparent envelope around a cold, opaque core.

Future Plans

The next step for this project is to run the program on selected areas, and analyze the results from these runs. We have also written a HI self-absorbtion version of the code that can be implemented in the same manner as its emission counterpart.

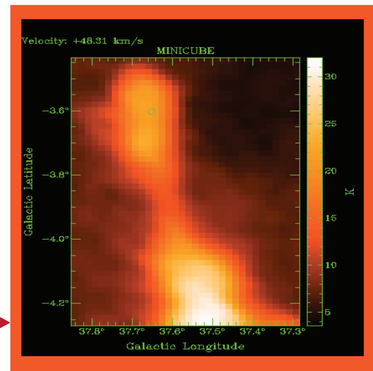
Acknowledgements

Our data came from the Arecibo radio telescope, which is funded by the National Science Foundation. Our analysis used the IDL software environment. We thank Western Kentucky University for computing facilities and financial support.

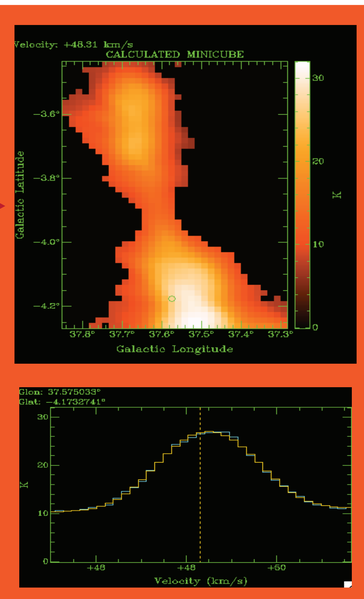


The data are collected by observing the photons emitted from the 21-cm spin flip transition. The image to the left shows the glactic disk located. This area is around 7000 light years away.

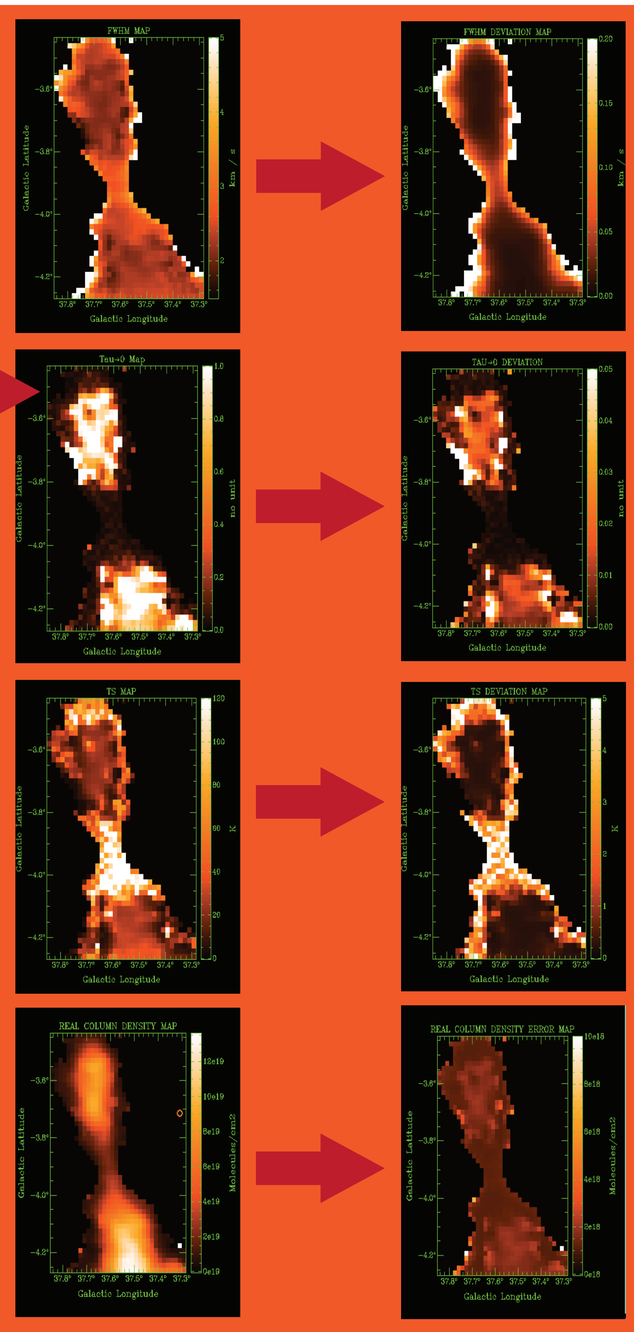
The image above shows one velocity slice through the original datacube before we apply our fitting algorithm. The feature of interest is behind the green circle at the bottom. The broad velocity spectrum is shown at the right.



The extracted region of interest of the original datacube (top) and the corresponding spectrum(bottom) after coordinates have been specified.

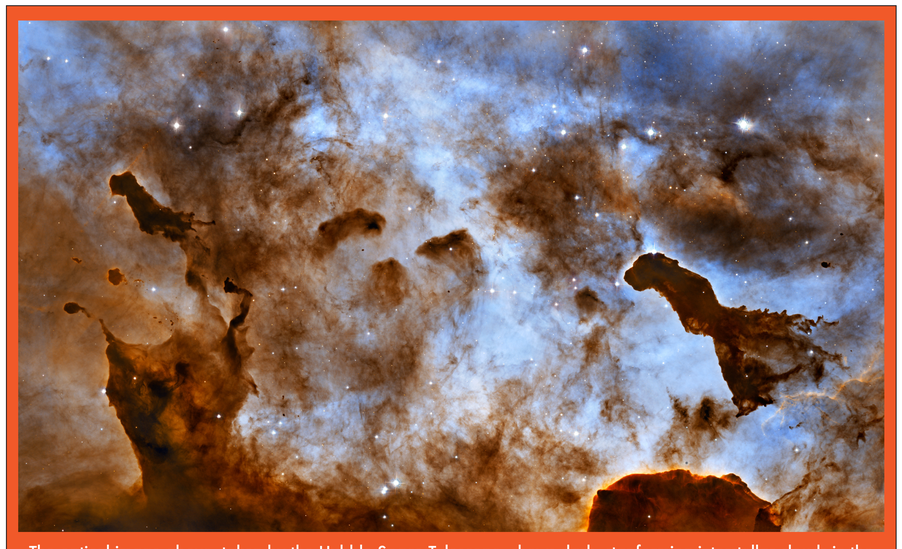


Top: data for which line fit can be obtained. Bottom: observed spectrum (blue) and model spectrum (yellow) resulting from best line fit with the 'amoeba' algorithm.



Several fitted paramater maps on the left with their deviation maps on the right, from top to bottom: line width, optical depth, spin temperature and real column density.

Pictured above is the Arecibo Radio Telescope located in Puerto Rico. The telescope has a diameter of 305m making it the largest and most sensitive single aperture radio telescope in the world.



The optical image above, taken by the Hubble Space Telescope, shows dark, star-forming interstellar clouds in the constellation of Carina. These are the optical counterparts of the cold, dense atomic hydrogen clouds we are looking for at radio wavelengths.

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