Angular Momentum of Galaxies in the ALFALFA Survey

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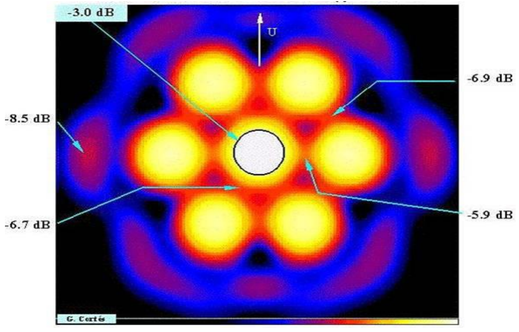
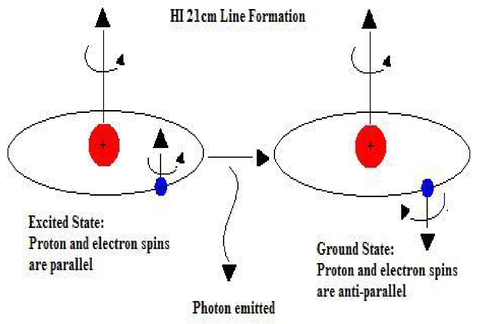
Background:

This is Arecibo observatory located in San Juan, Puerto Rico. Completed in 1963, Arecibo is part of the National Astronomy and Ionosphere Center (NAIC) funded by the NSF. The Observatory's 1,000 ft (305 m) radio telescope is the world's largest single-aperture telescope. The large dish reflects and focuses radio waves from the Universe.

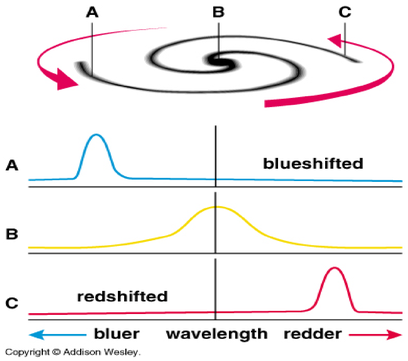


The ALFALFA survey exploits the Arecibo L-band Feed Array, dubbed ALFA. ALFA detects radio radiation at frequencies from 1225 to 1525 MHz. The array of feed horns allows for radio signal detection from 7 points on the sky simultaneously. ALFALFA uses overlapping drifts, so each pixel combines info from all 7 beams.



What is ALFA observing? About 99% of the interstellar medium (ISM) is gas, of which, 90% is Hydrogen. Hydrogen that is not diatomic is referred to as neutral hydrogen (HI). The transition between parallel and anti-parallel spins of the proton and electron emits a photon of 1420 MHz or 21 cm. This is detectable by Arecibo. It's lifetime is around 10 million years, but at any given time enough hydrogen atoms are emitting the 21 cm radiation to be detected. From external galaxies this emission is easily observed without any visible starlight and is observable in any region where large quantities of cold hydrogen exist. Because radio waves travel through mediums readily, this radiation is distinguishable on Earth.

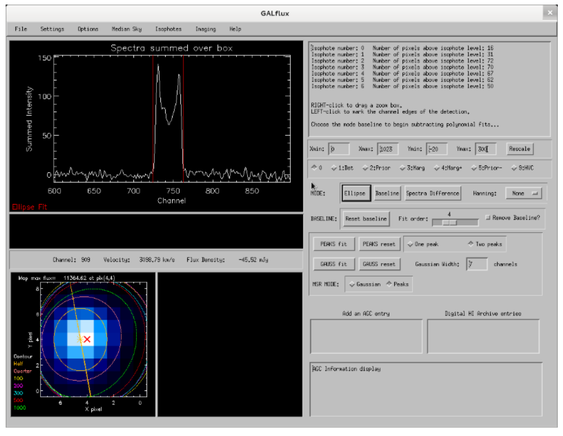
Motivation:



Moreover, the Universe is expanding. This means that all distant galaxies are receding relative to us on Earth. Thus all the HI lines are redshifted. And because we know the rest frequency, we can determine the velocity of the galaxy moving away from us (known as the heliocentric velocity) and how far away this galaxy is from Earth. HI is most evident in spiral and irregular galaxies. Many galaxies experience a differential rotation (meaning the parts closest to the center take less time to orbit than parts farther away). Half of the galaxy will be slightly blueshifted (approaching us) and the other half will be redshifted (receding). This causes a two "horned feature". Galaxies that contain this feature are ideal for my purposes of trying to determine the rotation signature.

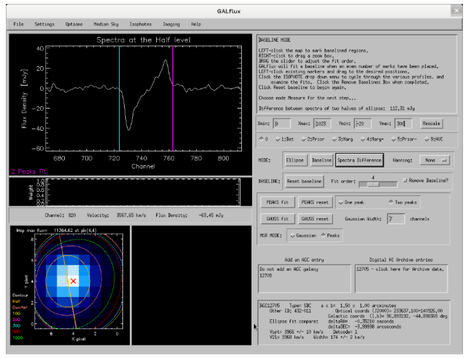
The ALFALFA survey is an on-going blind extragalactic HI survey that has detected more than 30,000 extragalactic HI line sources out to z~0.06. Using ALFALFA survey and optical data (i.e Sloan Digital Sky Survey and NASA extragalactic database) we are looking for correlations between angular momentum vectors between local neighbors and within galaxy groups. I have worked to determine the direction of the rotation of galaxies. Previous research found marginally significant correlations using HI to determine the angular momentum of galaxies . Our hope was to expand the dataset and resolve the ambiguity in directions and determine whether the correlations previously found are significant or not.

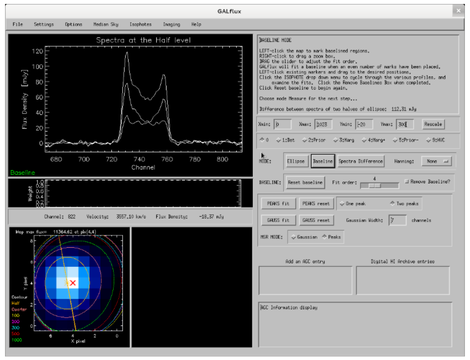
Results:



Methods of Observation:

The programs utilized are called GRIDView and *GALflux* and are created and run in an IDL environment. GRIDView allow for the viewing of three-dimensional data cubes of various sky maps. Declination increases going up. And right ascension increases as you move left in an easterly direction. You can shuffle through various cz values or redshift value multiplied by the speed of light. Smaller cz values mean not receding as quickly and therefore closer to us. Each channel shows the various flux density given in mJy per beam.





To initiate the *GALflux* procedure we measure the flux over the given pixels that experience flux due to a galaxy. *GALflux* displays the HI signature over the selected pixels for all channels. We then fit an ellipse to the HI flux of the various isophotal contours (specifically at half power). Then by dividing the flux of the two horned feature we can determine the flux on each half of the ellipse representing the flux from each half of the rotating galaxy.

Limitations:

Because ALFALFA uses overlapping drift scans the composite of all the beams is slightly broadened causing less resolution for galaxies of smaller angular extant. Thus, we are limited to larger angular sized galaxies where it is easier to distinguish signal from noise. We had hoped to be able to determine the rotation of dwarf galaxies and those with less HI content. However, those are not well resolved.