FUTURE SPECTRAL LINE RESEARCH WITH THE VLA

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The Very Large Array (VLA) is presently being constructed on the Plains of San Augustine near Socorro, New Mexico by the National Radio Astronomy Observatory. The purpose for which this instrument is being constructed is to produce "radio images" of resolution comparable to that of large optical telescopes. There have already been several "test" observations, some successful, using the partially completed instrument to study the molecular species of OH, H_2O, and NH_3 with wide bandwidths (200-1500 kHz).

Let me briefly describe the VLA for those unfamiliar with it. When completed the VLA will consist of twenty-seven 25-meter antennas arranged in an equiangular wye configuration. The collecting area of these telescopes is equivalent to a 130 meter telescope. One arm of the wye is almost due north (azimuth 354°59'42"). Each arm of the wye will have nine antennas arranged in a power law configuration to give good coverage in the U-V plane. The antennas can be moved along the wye to give four configurations, denoted by A, B, C, and D, of a maximum length from the center of the wye of approximately 21, 6.4, 1.9, and 0.6 kilometers respectively. This allows a range in resolution of 35:1. The operating frequencies of the array are in the L, C, U, and K microwave bands. For example, the resolution at L band (1600 MHz) will vary from $1\overset{''}{.}1$ (A configuration) to 37" (D configuration) while at K band (22235 MHz) the corresponding resolutions will be $0\overset{''}{.}08$ and $2\overset{''}{.}7$. Putting this into galactic perspective, operation at L and K bands in the A array will give spatial resolutions varying from 10^{15} to 10^{14} cm respectively for stellar objects such as OH and H_2O masing late-type stars located at 100 pc. For the large molecular cloud complexes, located $\sim$ 5 Kpc, the more sensitive D or C configuration will yield resolutions of 3-9 x 10^{17} cm for studies of H_2CO (4830 MHz) and of 0.6-2 x 10^{17} cm for studies of NH_3 ($\sim$ 23 GHz).

There are four IF channels which in the normal operating mode carry the opposite senses of circular polarization and their cross products. The signals from the antennas are transmitted via a waveguide transmission systems to the control building where the signals are processed.

B. H. Andrew (ed.), Interstellar Molecules, 627–629.

The maximum IF bandwidth is 50 MHz. The bandwidth may be reduced and by use of a recirculating correlator the number of channels may be increased. At 50 MHz IF bandwidth 16 channels are available. The number of channels doubles each time the bandwidth is halved, reaching a maximum of 512 at 1.5625 MHz. The minimum IF bandwidth will be 97.7 kHz. A present limitation of 256 channels is set by the capacity of the asynchronous computer. Two hundred and fifty-six is the total number of channels available for all four IF channels. If one wishes to observe polarization using all four IF channels, the resolution will be 64 channels at present. This corresponds to a maximum frequency resolution ranging from 0.3-0.02 km s^{-1} at L and K bands, respectively, using the narrow 97.7 kHz IF bandwidth.

Although the operating frequencies were chosen primarily to include protected radio bands, they contain many spectral lines. In the L-band waveguide range (1340-1730 MHz) atomic hydrogen, together with the molecules of formamide, formic acid and OH, is present. In the C band waveguide range (4500-5000 MHz) OH and formamide are present along with formaldehyde. At U band (14400-15000) there is again formaldehyde, while in the K band range (22000-24000 MHz) there is water and ammonia. In all four frequency bands the recombination lines of hydrogen and helium can be observed, ranging from the H169α to H65α hydrogen lines.

The capabilities of the VLA should lead to improved studies of masing as well as thermal lines. Studies of masing regions of OH and H_2O will lead to improved positions exceeding $0\overset{''}{.}1$ in accuracy for these objects. For the ground state OH ($2\pi_{3/2}$ J = 3/2) and H_2O masers the positional accuracy will probably be limited only by the structure of the individual masers themselves, and will perhaps allow the measurement of the parallax and proper motion of late-type stars along with motions caused by stellar companions. Many of these masers such as the H_2O masers associated with late-type stars are large in apparent size (10^{14} cm). VLA measurements will allow the study of all the maser radiation. In the past, VLBI observations, which are sensitive to components of size $0\overset{''}{.}1$-$0\overset{''}{.}001$, have been unable to detect large features.

Study of atomic hydrogen will lead to knowledge of galactic structure on the 10^{15}-10^{17} cm scales. These studies will be complimented by studies of high velocity clouds and OH absorption.

Molecular species such as formaldehyde and ammonia will yield information on temperatures of molecular clouds without worry about filling factors. With regard to ammonia in the galactic center, the question of clumping or size structure on the arc second scale can be answered.

The kinematics of clouds may be studied via the recombination lines or molecular transitions. The hydrogen/helium abundance may be studied in detail in regions such as the galactic center at a resolution of 10^{16} cm. The recombination lines of carbon may also be studied. The positional accuracy will exceed one arc second in all cases.

In addition to galactic studies, the sensitivity of the VLA will make it the premier instrument for studying extragalactic radiation. Combining all the antennae in a single dish mode will be equivalent to a 130 meter instrument, making it the most sensitive antenna at frequencies as high as K band.

In summary the VLA will allow significant advances in the study of molecular clouds through its increased sensitivity and resolution allowing direct comparison of transitions found in the radio range of the spectrum with those in the infrared, optical and UV.

DISCUSSION FOLLOWING JOHNSTON

Snyder: Has the VLA been used successfully for any molecular observations? If so, can you comment on the positional accuracy of the molecular observations?

Johnston: The VLA has been used successfully to observe OH masers at 1612 MHz. These sources are very intense, making them easy to detect when observed with a bandwidth much larger than the inherent linewidth. After September 1979 narrower bandwidths will be available, leading to an operational spectral line system by the end of 1980. The current accuracy of VLA positions should be calculable from observations of OH masers in May 1979 by Reid, Moran and myself. The rms error from least squares fits to position from the observed phases was about 0$''$.1, but we have not yet evaluated the systematic errors in the observations. The positional accuracy of the VLA when it is in full operation should easily be better than 0$''$.1 for maser sources and probably should approach 0$''$.01.

T. Wilson: What are the plans for the VLA spectral line system?

Johnston: In my talk I limited myself to describing the basic operating system, making no reference to the processing of the data after the observations are completed. By the end of 1980 there should be a limited capacity at the VLA for making maps of spectral line sources. Plans are now being formulated for handling the large volume of data resulting from spectral line observations. Editing of data and the displaying and cleaning of maps of specific lines at specific radial velocities will be possible.

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