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RADIO ASTRONOMY

Ken Tapping, 13th November, 2018

As you come onto our observatory site, you get a good view of the assortment of antennas that act as the signal collectors for our radio telescopes. In front of you, in the distance, near the laboratory and workshop buildings, is the 26m dish antenna. On the right lie the four huge troughs of the antennas for the CHIME (Canadian Hydrogen Intensity Mapping Experiment) and on your left the railway track and seven 9 metre antennas making up our Synthesis Radio Telescope. These antennas, spread over a 600 metre east-west line, form a radio camera, making images of the sky as we would see it if we could see radio waves. Recording an image takes about 10 days, with the antennas being moved to different positions each day. The result is a radio image with about the same level of detail at radio wavelengths as we get with the unaided human eye, using visible light.

So, why do we bother with radio telescopes? We do it for the same reason as we do astronomy at infrared and other wavelengths. Different wavelength ranges give us completely different views of the universe and what is going on in it.

Electromagnetic waves, which include gamma rays, x-rays, ultraviolet, infrared and radio waves, are distinguished only by their wavelength. Gamma rays have the shortest wavelengths and radio waves the longest. All these waves come in little packets called quanta, which cannot be broken into smaller bits. The amount of energy needed to make one quantum of electromagnetic waves depends on its wavelength. If the required energy to make quanta with a particular wavelength is not available, those quanta will not be produced. Radio quanta have the lowest energy of all, and can be produced in regions with insufficient energy to produce anything else.

A good example is the cold, dark material forming the dark lanes and blobs in the Milky Way. We can only see this material optically because it is sitting in front of stars and glowing clouds of gas. In fact there is a lot of that dark, cold stuff out there, and radio telescopes can detect and image it. We have found that this material makes up most of the stuff in our and most other galaxies. It is the raw material for making new stars and planets, and its gravity has a large say in what goes on, so we are very interested in mapping and studying it and how it behaves. At other radio wavelengths, the gas and dust clouds are transparent and we can see what is happening beyond. There are lots of distant, high-energy objects that give off radio waves as well as light and other waves, which we can only see with radio telescopes because our optical view is blocked by clouds of gas and dust.

Probably the biggest asset to radio astronomy is the radio emission produced by cold cosmic hydrogen gas. Hydrogen atoms are the simplest in nature; they consist of a single proton with a solitary orbiting electron. Occasionally, due to starlight or other causes, the electron flips over, and when it flips back, it gives off a quantum of radio emission, with a wavelength of 21 cm. Since there are a lot of hydrogen atoms out there, this emission can be detected by radio telescopes and the clouds of hydrogen gas imaged. This is one of the main purposes of our Synthesis Radio Telescope. Over the last ten years or so, the hydrogen clouds in our part of the galaxy were mapped as part of the Canadian Galactic Plane Survey. The project also included mapping the hot clouds of gas near new-born stars and counting the radio galaxies and quasars lying far beyond our galaxy. Over the last couple of decades we have found that many of the molecules forming and reacting in those cold, dark, gas and dust clouds have detectable radio signatures, and many of them play roles in the chemistry of life.

Venus lies low in the dawn glow. After dark Mars is low in the south and Saturn low in the southwest. The Moon will reach First Quarter on the 15th.

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