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WAVE MESSAGES

Ken Tapping, 14th June, 2016

Almost everything known about the universe beyond the Solar System we have learned by studying the electromagnetic waves coming from it. For most of our history we have observed the visible light from the cosmos. Almost all of this comes from stars. We can see other things if they are lit by stars or are silhouetted because they lie in front of things lit by stars. However, most of the cosmos is invisible, because it is cold, emits no light and is not close enough to a star to be illuminated by starlight. Fortunately, over the last few decades we have developed the technologies to see other radiations from space. This has revealed a cosmos that was previously hidden from us, and one that is very different.

Electromagnetic waves comprise gamma rays, X-rays, ultraviolet radiation, visible light, infrared radiation and radio waves. The only difference between them is their wavelengths – the distance between two wave crests. Visible light has wavelengths ranging from about 400 billionths of a metre (which we see as blue light), to 800 billionths of a metre (red light). Radio waves have wavelengths ranging from millimetres to many tens of metres, even kilometres. X-rays have wavelengths in the range 0.01 to 10 billionths of a metre. Gamma rays are even shorter.

Electromagnetic waves come in little packages called quanta. There is no such thing as half a quantum. To make a quantum of radiation at a given wavelength requires a certain, fixed amount of energy. The shorter the wavelength the more energy is needed. This provides us with a very powerful research tool. For an object in the sky to produce emissions of a certain wavelength, that object has to have the energy needed to do it. The enormous amount of energy needed to make gamma rays and high-energy X-rays is only found around neutron stars and black holes. Gamma rays originate in nuclear reactions. The problem with studying these short-wavelength, high intensity radiations is that we have to observe them from space. They are blocked by the atmosphere. This is fortunate for us because they are very dangerous to living things.

Stars produce light and infrared radiation (heat), along with some low-energy X-rays. Even the cold, dark clouds of cosmic gas and dust, with temperatures around -250 C are energetic enough to make long-wavelength infrared radiation and radio waves. Radio telescopes like the ones here at the Dominion Radio Astrophysical Observatory (DRAO) and the Atacama Large Millimetre Array (ALMA) radio telescope in Chile -- in which we have a share – make it possible to see what these clouds are doing, what they are made of and what is going on inside. We can see new stars and planets being born, and observe the witches' brew of chemicals forming and reacting together, telling us something about the chemical basis of life.

Over the almost 14-billion year life of the universe, the heat of the beginning has been spread throughout our expanding universe, and is now equivalent to a temperature of about -270 Celsius. Our radio and infrared telescopes can detect that heat and map it too, revealing the seeds of the first stars and galaxies. We have a new radio telescope under construction here at DRAO, called the Canadian Hydrogen Intensity Mapping Experiment (CHIME) designed to map the young universe.

When we look at the night sky, what we see looks serene, beautiful and peaceful. It is only when we make observations at other wavelengths, revealing exploding stars, stars being born, black holes, neutron stars and the Big Bang, that we realize that the universe is not that serene after all. A lot of very dynamic things are happening out there.

After sunset Jupiter is high in the southwest, and Mars and Saturn lie in the southern sky. Mars is the bright one; Saturn is fainter and to Mars' left. The Moon will be Full on the 20th.

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