Starlight's message

Tapping, Ken

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/23000227
Skygazing: Astronomy through the seasons, 2015-04-14

STARLIGHT'S MESSAGE

Ken Tapping, 14th April, 2015

We have a fish tank at home, and on spring mornings, the Sun shines diagonally through it. The tank acts as a prism, projecting on the wall the rainbow of colours making up sunlight. The colours are really lovely. They are also intriguing, because in that rainbow the Sun is telling us about itself.

What is happening here very much resembles the experiment done by Isaac Newton in the 18th Century. He passed a beam of sunlight through a prism – a glass wedge, and found that the yellow-white light we get from the Sun is made up of the colours of the rainbow. He established that what we see as white light is a mixture of specific amounts of red, orange, yellow, green, blue, indigo and violet light, all blending into one another. Newton had found out something about white light, but did he realize he had given us one of the most powerful tools we have for studying even the most distant part of the universe – spectroscopy?

Even with the "fish tank spectrometer" we can find out useful things about the Sun. We know that the Sun is a big ball of hot gas, but by measuring the relative proportion of the different colours in that spectrum projected on the wall we can estimate the temperature of the part of the Sun giving off that light. We get a temperature of about 6,000 C. As we would expect from experience with hot objects, a larger contribution by reddish colours indicates lower temperatures and a larger contribution from the blue end of the spectrum means higher temperatures. For example, Betelgeux, the red star marking Orion's shoulder, has a temperature of about 3,000 C, Arcturus, the orange star in the east these evenings, comes in at about 4,300 C, and Sirius, the brilliant, blue-white star in the south-west these evenings comes in at about 10,000 C.

There is more to the "message of starlight" than that. Analysis of sunlight and starlight using a proper spectrograph shows that in addition to the rainbow of colour that tells us the star's temperature, there are lots of narrow, dark lines. These are the signatures of atoms in the star's atmosphere. Resonances in the atoms pick up particular wavelengths of light and then reradiate it in all directions, so at that wavelength there is less light coming in our direction, forming a narrow, darker line against the bright background. The atoms of each element have their own unique patterns of resonances, which makes them identifiable. We can see what the star is made of, no matter how far away it is.

There's more. Space is full of clouds of cold, dark material. When a bright, young, blue star is born in a cloud nearby, the ultraviolet these stars emit excites the atoms in the clouds, so they give off light at the various wavelengths due to those same resonances in those atoms. So our spectrometers show a spectrum with just bright lines, once again telling us what those clouds are made of.

There's another thing. We are all familiar with how the pitch of sirens on emergency vehicles or horns on trains is lower when they are moving away from us. Christian Doppler first explained this process, so it is now called the Doppler Effect. The movement of objects in space might be bringing them closer to Earth or further away. If they are approaching, spectra line emissions are moved to a higher pitch (shorter wavelength); we call this "blueshift" because it makes the light look bluer), and if receding, to a lower pitch (longer wavelength); this is called "redshift" since it makes the light look redder. We can use this pitch change to calculate the velocity toward or away from us. This process is what revealed to us that our universe is expanding. All this is something to consider when you see some piece of glassware in your home making a rainbow out of sunlight.

Venus shines brilliantly in the southwest after sunset, with Jupiter almost as bright, high in the south. Saturn rises around 11pm. The Moon will be New on the 18th.

Ken Tapping is an astronomer with the National Research Council's Dominion Radio Astrophysical Observatory, Penticton, BC, V2A 6J9.
Tel (250) 497-2300, Fax (250) 497-2355
E-mail: ken.tapping@nrc-cnrc.gc.ca