Chemistry in space

Tapping, Ken

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/23001384
Skygazing: Astronomy through the seasons, 2017-01-31

CHEMISTRY IN SPACE

Ken Tapping, 31st January, 2017

Planets are not just big balls of rock. They comprise lots of other things too, like water and organic molecules, in which carbon is the principal ingredient. It is these molecules that form the foundation of life as we know it. Without them we would not exist. Where did they come from and how did they survive the hot and violent process of planet formation? We still have a lot to learn here, but thanks to modern astronomical instruments we are slowly getting the story – bit by bit.

The raw material from which planets – and stars – are formed lies in huge clouds of cold gas and dust. The outer parts of our and other galaxies have lots of it. In other galaxies we can even see the pinkish blobs where new stars have formed and are making their birth clouds glow. However, learning what is going on inside those clouds and what they are made of – what is the recipe for a planet – is more difficult. With optical telescopes we only see those clouds when something lights them up or something bright lies behind them.

We know those clouds are mostly hydrogen. During the Second World War Dutch physicist Hendrik van de Hulst calculated that cosmic hydrogen should produce radio emissions with a wavelength of 21cm. These were successfully detected by Harold Ewen and Edward Purcell in 1951. Mapping and studying cosmic hydrogen through its radio emissions has been a mainstay of the work at our observatory for decades. However, hydrogen is still a long way from the complex molecules making up living things on planets like Earth, and does not tell us what produced the initial carbon-based molecules needed to start the story of life, although they must have come from the Solar System's birth cloud. Fortunately two things make it possible to find out more. Firstly the fundamental properties of molecules and secondly the rapid advances in radio telescope technology that have been achieved over the last few years.

If you have a stringed instrument like a guitar in your house you will have noticed that if there is a loud, abrupt noise, such as a slamming door, the strings on the instrument will "sing". From the notes in the "song" you can deduce which strings are singing. In the unlikely event that instrument is both in tune and is moving rapidly away or towards you, the changing note – the Doppler Shift – will tell you how quickly it is approaching or receding.

Molecules have resonances too. Under the right conditions, hitting them with pulses of energy will make them resonate, and emit pulses of radio waves or light. The frequencies of those emissions identify the molecule making them. The problem is that most of the molecules we are interested in resonate at extremely short wavelengths. FM radio broadcasts are at wavelengths of around 3 metres. Radar systems operate at wavelengths of a few centimetres. Cosmic molecules resonate at wavelengths of millimetres or less. It has only recently become possible to make radio telescopes that can operate at these wavelengths. Making radio receivers to detect such emissions is technically very challenging and making dishes accurate enough to capture such short wavelengths is equally difficult. However we are getting there. The Atacama Large Millimetre Array, on a high plateau in Chile, is an array of 66 dishes with state of the art receiving systems. It is an international project in which Canada is a partner, with NRC developing sensitive radio receivers and other technologies as part of our national contribution. ALMA can detect emissions from the various molecules and dust particles in clouds that are in the process of forming new stars and planets. This will get us another page or two into the book on "How we got here".

Venus shines brilliantly, low in the Southwest after sunset. Mars, redder and much fainter, lies close to the left of Venus. Jupiter rises around midnight. The Moon will reach First Quarter on the 3rd.

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