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SEEING THROUGH FOG

Ken Tapping, 21st April, 2015

In astronomy, many of the things we would like to observe are hidden inside or behind thick, dark clouds of gas and dust. New stars and planets form in the depths of these clouds, and regions like the centre of our galaxy are hidden behind a huge thickness of cloud material. Luckily we are now able to penetrate these clouds and see star and planet birth happening, and are puzzling about the things we see going on at the centre of our galaxy. The cause of the problem we had to solve is a process called “scattering”. This is not something confined to space; we see it going on around us every day, but we notice it most when it is foggy.

Like cosmic dust, fog consists of a huge number of tiny particles, which in the case of fog are water droplets. Light from objects in or behind the fog hits these particles and is scattered off in other directions. This scattered light hits more particles and is deflected again and again. Since seeing something depends upon light passing in a straight line from it to our eyes, the fog can render it invisible, perhaps replacing it with a diffuse glow of scattered light. When driving in fog, dipped headlights are a little help, but high beams just produce a bright, diffuse glow, and don’t help at all. However, if the fog is not too thick, orange-tinted glasses are a tremendous help. It is intriguing that the process behind this solution is exactly what we do in astronomy to penetrate cosmic fog.

White light consists of a rainbow of colours, ranging smoothly from red, through blue to violet. Red light has a wavelength of roughly 0.8 millionths of a metre, blue light about half that. That difference in wavelength makes a tremendous difference to the degree of scattering. Blue light is scattered around 16 times more vigorously than red light. You can see this by looking at smoke from a wood fire. From the side the smoke looks blue due to scattered light; however, the Sun or Moon viewed through the smoke looks reddish because the longer wavelengths are far less scattered.

The orange-tinted glasses help so much when driving in fog because they reduce the amount of strongly-scattered blue light reaching your eyes, while allowing the less-scattered red light through. The result is an amazing increase in visibility. In principle, going to longer wavelengths, like infrared or submillimetre wavelength radio waves will work even better. At those wavelengths even thick fog or smoke is almost transparent. This is little value for driving since our eyes cannot see such wavelengths, but it is a boon for astronomers. This is thanks to the progress we have made over the last couple of decades into devices that can detect and image infrared and submillimetre wavelengths. These developments led to new telescopes, such as the James Clerk Maxwell Telescope and the Atacama Large Millimetre Array. The two Gemini telescopes were designed for optimum performance at infrared wavelengths.

Behind the dust and star clouds, the centre of our galaxy hosts a black hole, which is in the process of swallowing nearby stars. There are other things going on there that we are trying to understand.

We are finding that many of those dark cosmic clouds contain hundreds or more of embryo stars and planetary systems. In many cases the planet formation has scarcely begun and the star yet to fully graduate as a star. It is still shrinking and getting hotter in the middle, but nuclear fusion has not yet started, and the star has not “turned on”.

We are now seeing all the main phases in the lives of stars. However, saying that this tells us all about stars is rather like saying that knowing how people are born, mature and die tells us everything about people. That falls far short of the truth. We still have a lot to learn about people – and stars.

Venus shines brilliantly in the southwest after sunset, with Jupiter almost as bright, high in the south. Saturn rises around 11pm. The Moon will reach First Quarter on the 25th.

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