appeared in 2002

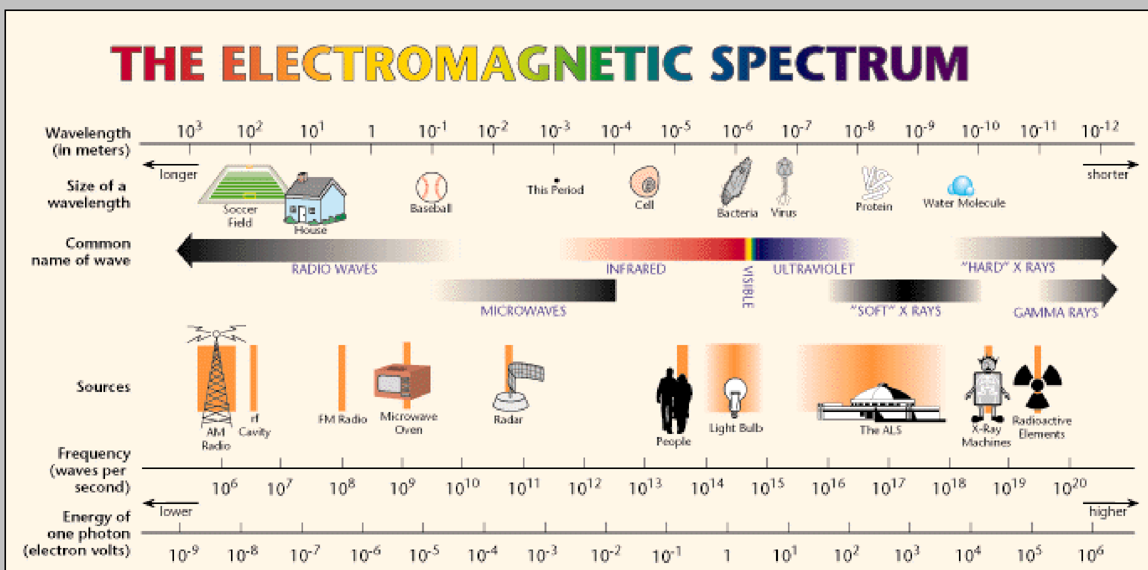
Nature’s coat of many colours

S.Ananthanarayanan

Nature’s great identification mark seems to be colour. From the exploring of galaxies billions of light years away to the study of molecules, and now, DNA, we keep coming back to the importance of colour in nature.

Colour , energy and spectra

Colour has to do with the wavelength of light waves, and the wavelength depends on the energy of the wave packet, or ‘piece’ of light. The more the energy, the shorter the wavelength. Violet light, X-rays, gamma rays have high energy and short wavelengths. Red light, microwaves, radio waves have low energy and long wavelengths.



Energy levels

These energies of light waves arise from changes of ‘energy level’ of atoms, molecules or atomic nuclei. When atoms or other systems go from a higher to a lower level, they emit a ‘photon’, or light particle, of precisely the difference of energy of the two levels. Inversely, it is by absorbing such a photon that they could rise to a higher energy level.

Now the elements have characteristic energy level differences and they can be uniquely identified by analyzing the components of light they emit. This is done with the help of something like a prism, though a lot more sophisticated, to analyse colours far removed from the visible range. When dealing with intergalactic clouds of gas, there may be no ‘emission’ of light to analyse, but if the light of a star passes through the cloud, then we could look at which colours the gas ‘absorbed’ and come to the same conclusions.

Short and long wavelengths

Atoms and nuclei of elements have energies that correspond to visible light or shorter wavelengths. Light at these wavelengths does not travel vast distances too well. To study X-ray spectra, in fact, we need to launch telescopes into space, to avoid the scattering by the atmosphere.

Apart from the atomic level, thermal, rotational and magnetic behavior of stars also gives off radiation, but of longer wavelengths, like the infrared, microwave or radio ranges. Radiation at these wavelengths can travel long distance without being scattered. Special arrangements to detect these radiations are used to study the farthest stars and galaxies.

Molecular spectra

Molecules also have vibration and rotational modes that emit and absorb long wavelengths. Here again, wavelengths are characteristic of particular molecules, or groups of atoms in molecules.

Analysing absorption spectra in the infrared and microwave regions is now the classic way to identify organic chemicals, check for purity, or even to analyse the detailed structure of complicated molecules.

Analysing DNA

Genetic research involves identifying individual DNA strands that attach to other strands during experiments. This enables identifying the specific DNA involved in genetic features, diseases of remedies. So far, true to the use of colour in science, the way to detect which strands of DNA took part in a reaction was to use ‘stains’. With various strands stained differently, the colour that enters the reaction product identifies the strand.

But stains do alter the DNA strands themselves and can distort results. Absorption spectra in the region between the infrared and microwave have thus become the industry standard.