A bane and a blessing
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A BANE AND A BLESSING

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Have you ever looked through a really cheap telescope or pair of binoculars? In addition to a probably dim, blurry image, you will have noticed that every object has a coloured border, red or blue. You can change the colour of that border by adjusting the focus, but you cannot get rid of it. These false colours, which can be quite attractive, are produced by a process called "chromatic aberration". Dealing with this has been one of the main thrusts of lens and telescope design for centuries. The work continues today, although modern, high-quality refracting telescopes (ones that use lenses to form the image), have to be pushed hard to show that problem.

The light we see with our eyes ranges in wavelength from about 400 to 800 nanometres (billionths of a metre). Our brains interpret that wavelength range as the familiar rainbow of colours extending from blue to red.

A lens collects all the light from each point in a distant object and focuses it all to a corresponding point in the image. It achieves this by bending the light so that it converges. This bending of the light is called "refraction", and the extent to which anything bends light is described as a number - the "refractive index". The problem is that in most materials, such as glass, the value of the refractive index depends on the wavelength. This makes the blue light in an image focus a different distance from the lens than does the red light. You cannot get all the wavelengths in focus at the same time, so the image formed by the focused light is fringed by the colours that are not focused.

This problem has been reduced and almost eliminated by making telescope, binocular and camera objectives from combinations of lenses made from different glasses with different refractive indices. The first lenses developed to beat the chromatic aberration problem were known as achromats. The current generations of these lenses are made out of even more exotic materials and are called apochromats. These show very little, if any chromatic aberration. It is intriguing though to note that chromatic aberration also turned out to be a blessing that revolutionized astronomy. It all started with Isaac Newton.

One day Isaac Newton passed a beam of sunlight through a prism (a glass wedge). Since the refractive index of the glass depended on the wavelength of the light, blue light was bent more than red light. The prism had taken the white light and broken it up into the band of colours making up light we perceive as white. It enabled us to analyze light by breaking it up into its colour components. Different atoms and molecules absorb or radiate particular wavelengths, leaving their signatures in the light. By analyzing that light using a prism we can determine what stars are made of, their temperatures and what sort of material the starlight is passing through on its way to us. Chromatic aberration led us to astronomical spectroscopy, an essential part of astronomy.

Isaac Newton, who first harnessed chromatic aberration for science, also devised an elegant cure for it. Instead of forming the image in a telescope with a lens, he used a mirror. A concave mirror with a reflective coating on its surface forms an image without the light passing through any glass at all. Therefore there is no chromatic aberration. His invention, the "reflecting" telescope, is now the mainstay of astronomical research. The Gemini Telescopes, the Canada France Hawaii Telescope and the Hubble Space Telescopes all use mirrors rather than lenses. We often put spectroscopes on reflecting telescopes, combining two of Newton's inventions, one avoiding chromatic aberration and the other exploiting it.

Mars and Venus lie in the Southwest after sunset. Venus is very bright. Mars, redder and fainter, lies close to its left. Jupiter rises around 10pm. The Moon will reach Last Quarter on the 18th.

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