The Mystery of Light

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The beauty of gems is conveyed to us through our eyes, by the medium of light. Without light, however, the sparkling diamond loses its luster and the ruby its fine red color. Without light, the world would be pitch black, and no one would ever be aware of the beauty of gem stones.

Almost from the dawn of civilization, this phenomenon of light and the way it reflects and projects has intrigued and puzzled scientists, and many conflicting theories have been formulated about its real nature. None of them fully explain this phenomenon, but the most convenient explanation is the wave, or undulatory, theory. According to this, light consists of electro¬magnetic waves that emanate in all directions in straight lines from a lumi¬nous source, such as the sun or an electric light bulb. One of the most puz¬zling features of light is its incredible speed. It takes only about 8 minutes for sunlight to reach the earth, and it has been calculated that fight travels through outer space at the phenomenal speed of about 186,000 miles per second. The most modern rockets and man-made satellites rarely exceed a speed of 20,000 miles per hour.

The famous English scientist, Sir Isaac Newton (1642-1727), made a funda¬mental discovery when he passed a narrow beam of white sunlight through a glass prism (see Fig. 14). He found that a beam of ordinary white light splits up into a colored band similar to that of the rainbow. Since then, it has become common practice to speak of white fight as being composed of seven principal colors—red, orange, yellow, green, blue, indigo, and violet. This is also called the solar, or visible, spectrum, and each of these colors gradually merges into the next one. This splitting up of light into its spectrum colors is known as dispersion and also occurs when light enters gem stones. The amount of dispersion a gem can produce determines its so-called fire— a characteristic of the utmost importance in colorless, transparent gem stones, for without this fire they would look dull and uninteresting. The sparkle of the diamond is due almost entirely to its great fire.

Each shade of the spectrum is produced by light waves of a fixed and definite wave length, and the colors seen in everyday life are usually a mix¬ture of several spectrum colors in varying proportions. Light waves are ex¬tremely short, so short in fact that a special unit, the Angstrom, had to be devised to measure them. An Angstrom unit, represented by the symbol A, is only Vi 0,000,000 millimeter in length. The longest hght waves produce red light, whose wave lengths may vary between 7,500 A and 6,500 A. The shortest light waves produce violet light and its wave length hovers between 4,000 A and 3,900 A. Figure 15 shows diagrammatically a violet and a red wave length. The wave lengths of visible light range from about 7,500 A, in the red part of the spectrum, to 3,900 A, in the violet part of the spectrum. Beyond 7,500 A he the still longer, and invisible, infrared and radio waves, and beyond the violet end of the spectrum lie the shorter, and invisible, ultraviolet rays, x-rays, gamma rays, and cosmic rays.

Let us take a closer look at the way light behaves by studying a ray of sunlight that falls upon an ordinary glass mirror. A mirror will reflect light, which always observes certain strict laws that govern its mode of travel. Take, for example, the mirror in Fig. 16. A O is a ray of light falling obliquely upon the mirror surface at O. The ray is turned back or reflected from the mirror surface along OR. Imagine OB to be a line drawn perpendicular, or normal, to the surface of the mirror at O. The interesting thing is that the angle of incidence,^ OB, at which the light strikes the mirror, is always equal to the angle of reflection, BOR; also, the incident ray, AO, the reflected ray, OR, and the normal, OB, lie all in one plane.

These are the laws of reflection and are observable often in daily life, for instance, the spot of light that appears on the ceiling of the living room when a ray of sunlight from the window is reflected from the surface of a cup of tea. The effects of light reflection are also of great importance in cut gem stones, and they play a large part in their lustrous and brilliant appearance.

Yet another phenomenon, which is called refraction, also plays an impor¬tant part in the appearance of gems. Imagine that a ray of light strikes the surface of a transparent gem stone; this is illustrated in Fig. 17. It can rightly be assumed that if a ray of light, AO, impinges on the surface of a transparent gem stone, part of the light will continue through the stone, but in¬stead of passing on in a straight line, the direction of the light changes, and it will travel in a direction similar to OR. This bending of the ray is called refraction, and when light is passing from a rarer medium, such as air, to a denser medium, such as a gem stone, the refracted ray, OR, is bent to¬ward the normal, BON. The incident ray, the normal, and the refracted ray are all in one plane. But if it travels the other way from the denser to the rarer medium, that is, from the gem stone into air, the ray will be re¬fracted from the normal, BON, along a path similar to OA.

One more peculiar property of mineral crystals is their ability to split light rays in two. All mineral crystals can do this with the exception of those, such as the diamond, belonging to the cubic system. This phenomenon is called double refraction (see Fig. 19), and if light enters such a mineral crystal, the light rays are not only bent, but they are also split, generally into two re¬fracted rays, which will take different paths. In the drawing, AO represents the incident ray, OR and OR' axe the two refracted rays. BN is the normal. This ability to split light is demonstrated in Fig. 20 by a large crystal of Iceland

spar, one of the strongest doubly refractive minerals known. Many gem stones exhibit this property, and, in some cases, it forms a useful key to their identification.
It is obvious that the subject of light is also closely connected with the color of gems, and it is not an unreasonable question to ask why the ruby looks red.

The answer to this question is color absorption. Different substances have the power to absorb different wave lengths of light, and the ultimate color of a gem or any other material will depend on the kinds and amounts of wave lengths that are not absorbed by the substance. In the ruby certain chemical substances are present that will absorb all wave lengths of light except those that look red to our eyes. As a result, the ruby looks red. Even a colorless, transparent stone, such as the diamond, will absorb a little light, but all wave lengths will be absorbed in the same proportion, and it will therefore remain colorless.