Laser Article Brought Into Focus

In reading the August installment of "Laser Experiments," I found what I believe to be several serious errors. First of all, a diffraction grating does not consist of thousands of very small parallel prisms per millimeter, as suggested. In actuality, a diffraction grating consists of many closely spaced parallel lines scored onto an aluminized plastic or polished glass surface. Those lines break up light into its component frequencies by the physical process of diffraction (the interference produced when light encounters an obstacle), as their name implies. Each scratch serves as a source of scattered light. Prisms operate through the entirely different process of refraction-the selective bending of different light wavelengths as they pass from one media (such as air) to another (such as glass). If gratings really operated as microscopic prisms as suggested, then they would have to be called refraction gratings!

Another type of grating consists of many parallel apertures or obstacles that ideally present a pass-block squarewave type pattern to the incident wave front. Yet another type (there are many), called a "blazed" grating, consists of grooves cut onto a glass surface whose serrated edges do resemble an array of prisms but which still operates by diffraction. Consult any standard physics or optics text for more details.

Another statement in the article suggested that the focusing of "light" is somehow more crisp and pronounced than that obtainable by other forms of electromagnetic energy such as "radio or sound." The big error here is that sound is not a form of electromagnetic energy. In addition, there is no fundamental difference between radio waves and visible light. They are both EM waves that differ only in their frequency. Radio waves are routinely focused by parabolic antennas and the like.

A further misconception was that placing black tapes around a bent glass rod would act as a shield to keep light from escaping out the sides. In reality, the process called "Total Internal Reflection" is what keeps light trapped within the rod or optical fiber. To operate, the incident light rays must enter the rod at an angle less than some critical angle determined by the material of the rod or fiber and the surrounding medium. If the incident angle exceeds that value, or if the rod/fiber is bent too sharply, then light can indeed leave through the sides. However, black tape will not redirect the light back into the pipe or cause Total Internal Reflection to occur, as implied.

Several times in the article, the author mentioned that lasers are coherent and monochromatic, but still contain all the other colors in the visible spectrum (albeit in small quantities). Thus, the article continued, colored light can be produced by passing laser light through a prism or a frosted plastic sheet. While it is true that no laser is perfectly monochromatic (the frequency spectrum is predominantly distributed over a band known as the line width), its bandwidth is extraordinarily narrow. For a common He-Ne laser, the line width is roughly 1500 MHz, which might seem large compared to radio frequencies but is less than l/1000 of one percent of the visible light spectrum. Technically, all frequencies in that narrow band are of different "colors." But to suggest that a full-color spectrum can be obtained through refraction of laser light is nonsense. Lasers are called monochromatic or quasi-monochromatic for good reason. Any colors thus perceived are due to interactions with ambient sunlight or non-monochromatic room illumination.

The use of the word "sub-reflection" to describe the speckling effect produced by shining laser light off a diffuse surface is non-informative. The speckles are caused by a stationary interference pattern set up in the space in front of the surface. Due to the long coherence length of the laser light, individual reflections from the rough surface combine together coherently at each point in space with a random but stationary (non-changing) phase to create the speckles. When viewed in sunlight, the speckles might take on various colors.

While lenses are extremely important in optical science, the rules that govern the focusing of laser light (Gaussian beams) are not quite the same as those for non-coherent light. This difference had disastrous consequences for some early designers of optical systems using lasers, who used the standard rules of geometrical optics and couldn't figure out why their systems failed to work! The interested reader can find a wealth of information on these topics in the many available books on lasers, optics, laser electronics, holography, and other related fields.

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