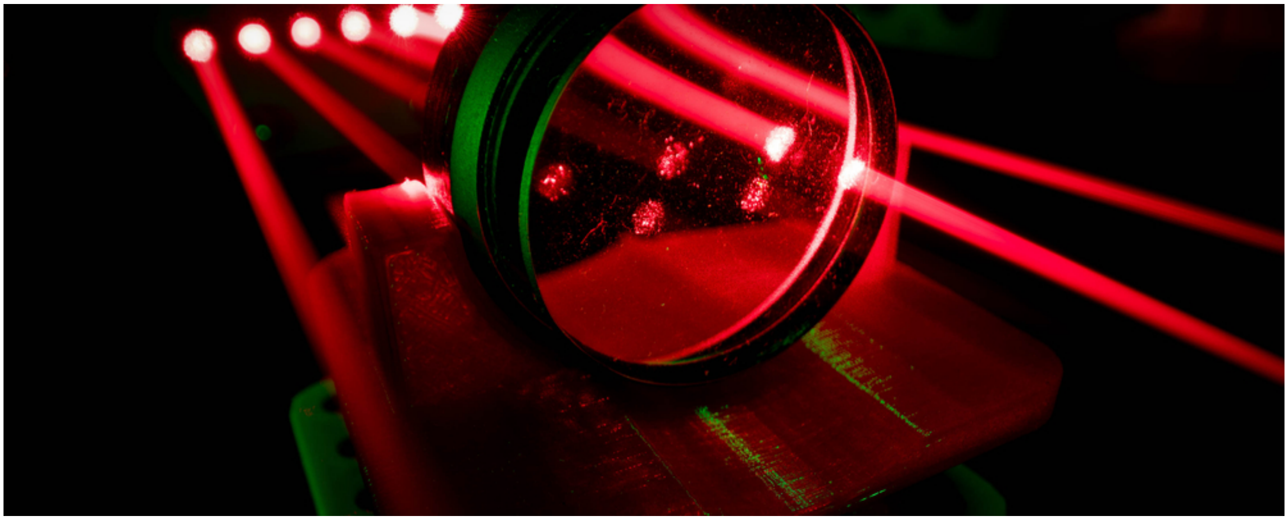
LASER Wavelengths: Generation and Modification

“Laser” (**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation) technology has proved useful in many applications, from scanning product barcodes at the local supermarket to atomic imaging in sophisticated particle physics labs. The hallmark of these devices is the narrow, intense beam of light they produce, but differences in laser construction allow the particulars of the generated light beam to vary greatly. Below, we will take a closer look at how laser wavelengths are determined, discuss means to modify standard wavelength emissions, and explore real world applications for wavelength modification.



Laser Wavelength Determination

A basic laser begins with the passing of light or energy through a central material (called gain media) such that the cascade of photons produced mimic one another in energy and phase. This process is repeated as the light continues to bounce between mirrored surfaces on the ends of what’s known as an optical resonance chamber. The wavelength such a laser will generate is dependent on both the gain media used and the length of the resonance cavity. To achieve resonance, the wave must satisfy the following equation: N? = 2L, where N is an assigned mode number related to the number of wavelength nodes possible in the space, ? is the wavelength, and L is the length of the resonance chamber. Once this wave pattern is established, the gain medium dictates the actual wavelength(s) emitted based on the material’s bandwidth limitations.

Modification of Natural Wavelengths

Working within these laws of physics, the wavelengths naturally produced by a laser can then be modified. As noted above, changing up the laser media will impact the range of wavelengths possible, as would modifying the size of the optical resonance chamber. Beyond this, wavelengths can also be selectively modified or even blocked by introducing elements like laser filters to the setup. A notch filter, for example, might be installed to block different center wavelengths (which are called the "stop band") while allowing other wavelengths to pass through (the "passband").

Practical Applications

There are many practical applications to wavelength filtering. For example, this practice is often necessary when performing Raman spectroscopy. Raman spectroscopy relies on laser light scattering in uncommon but predictable ways after encountering a compound's unique molecular structure. Much of the light that strikes the molecules will pass through unchanged in form and energy and is not useful to the scientists employing the technique. To prevent the instrument readouts from being inundated with this large, unnecessary original wavelength, a notch filter is typically installed to block it from transmitting.

The ability to modify laser wavelengths has played a big role in the laser's rise to ubiquity. As subtle changes to resonance chamber construction are made, different gain media are introduced, and features like filters are added, the laser becomes adaptable to many different settings and unique purposes. Raman spectroscopy is just one example among many applications, and no doubt, emerging fields will continue to benefit from adaptable laser wavelength technology.