

# Prop

## Properties of laser light

### 1. Monochromatic

The emission of the laser generally corresponds to just one of the atomic transitions of the gain medium, in contrast to discharge lamps, which emit on all the transitions. The spectral line width can be much smaller than that of the atomic transition. This is because the emission is affected by the optical cavity.

### 2. Coherence

Laser beams have a high degree of spatial and temporal coherence.

Spatial coherence refers to whether there are irregularities in the optical phase in a cross-sectional slice of the beam.

Temporal coherence refers to the time duration over which the phase of the beam is well defined. In general, the temporal coherence time  $t_c$  is given by the reciprocal of the spectral linewidth  $\nu$ . Thus the coherence length  $l_c$  is given by:  $l_c = c t_c = c/\nu$ .

### 3. Directionality

This is perhaps the most obvious aspect of a laser beam: the light comes out as a highly directional beam. This contrasts with light bulbs and discharge lamps, in which the light is emitted in all directions. The directionality is a consequence of the cavity.

### 4. Brightness

The fact that the light is emitted in a well-defined beam means that the power per unit area is very high, even though the total amount of power can be rather low. Then we must consider that all the energy is concentrated within the narrow spectrum of the active atomic transition. This means that the spectral brightness is even higher in comparison with a white light source like a light bulb. For example, the spectral brightness of a 1 mW laser beam could easily be millions of times greater than that of a 100 W light bulb.

### 5. Ultrashort pulse generation

Lasers can be made to operate continuously or in pulses. The time duration of the pulses  $t_p$  is linked to the spectral bandwidth of the laser light

$\nu$  by the “uncertainty” product  $t_p \nu \sim 1$  :  
 $t_p \geq 1/\nu$ .

This follows from taking the Fourier transform of a pulse of duration  $t_p$ . Dye lasers typically have gain bandwidths greater than  $10^{13}$  Hz, and can be used to generate pulses shorter than 100 fs (1 fs =  $10^{-15}$  s). This is achieved by a technique called “mode-locking”.