# Polarisation – What is Polarisation?

Polarisation is a fundamental property of waves. Transverse waves can have many polarisation orientations, whereas longitudinal waves like sound only have one. Optics generally deals with transverse waves, so these will be examined in more detail.

In a transverse electromagnetic wave the electric and magnetic fields oscillate perpendicular to the direction of travel and to each other. These transverse waves can be described as a sinusoidal function. One can think of light as a sine wave oscillating along a line. The wave can oscillate in many different directions in the Cartesian plane (x,y,z). If the wave was travelling in the z direction, the sine wave could oscillate in any direction along the x and y planes. If the wave oscillates in one direction, it is ***linearly polarised***. Any linear polarisation can be described as a superposition of two orthogonal linear polarisation states, one in the x-axis and one in the y. Because of this, light can be split up into orthogonal polarisation states (s and p polarisation).

However, light is not made up of a single wave. It is made up of a large combination of waves, which interfere to form the light we see. Unless a polariser has been used (to be discussed in another technical note), it is highly unlikely that all of the light waves will oscillate in the same way. The ***polarisation state*** of the system is the resulting polarisation from the combination of the x and y components of each sinusoidal wave.

There are three main types of polarisation: **Linear**, which we have already discussed, **Circular**, and **Elliptical**. The latter two are made up of a combination two linearly polarised waves that are out of phase. Their interference pattern and oscillation causes the wave to look like a rotating circle or ellipse, rotating perpendicular to, and travelling along the direction of motion. Elliptical polarisation is the general case, with circular polarisation only occurring at phase shifts of ±90°.

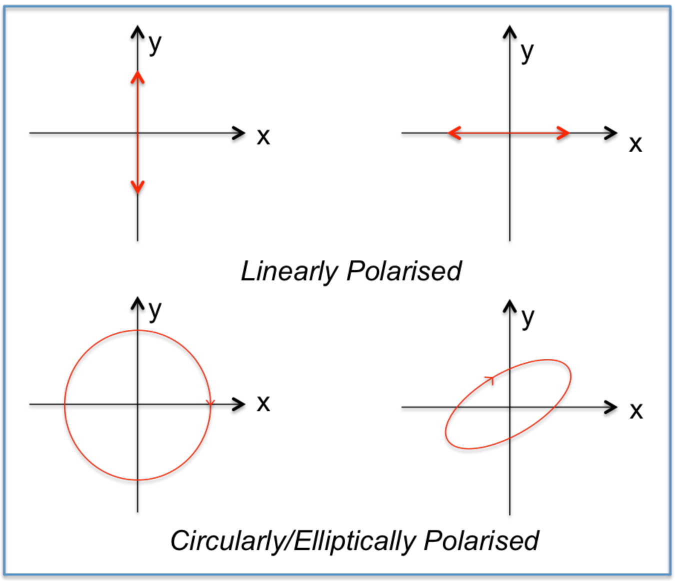


*Figure: Polarisation as viewed from the z-axis.*

It is useful for physicists to work with conventions, that anybody in the field will be able to understand when discussing or reading about a given topic. The same is true for optics. When describing the linear polarisation of light, it is most often described in a particular way.

When observing light incident on a surface, one can define the plane of incidence. This is defined as the vector component of the incident ray perpendicular to the reflecting surface. This can be observed in the figure bellow.

One can then describe the polarisation of the ray as being parallel, or perpendicular to the plane of incidence. Parallel rays are denoted by a p, and perpendicular by an s (from the German *senkrecht*). In Optical descriptions, the polarised ray in use is described as s-polarised or p-polarised.

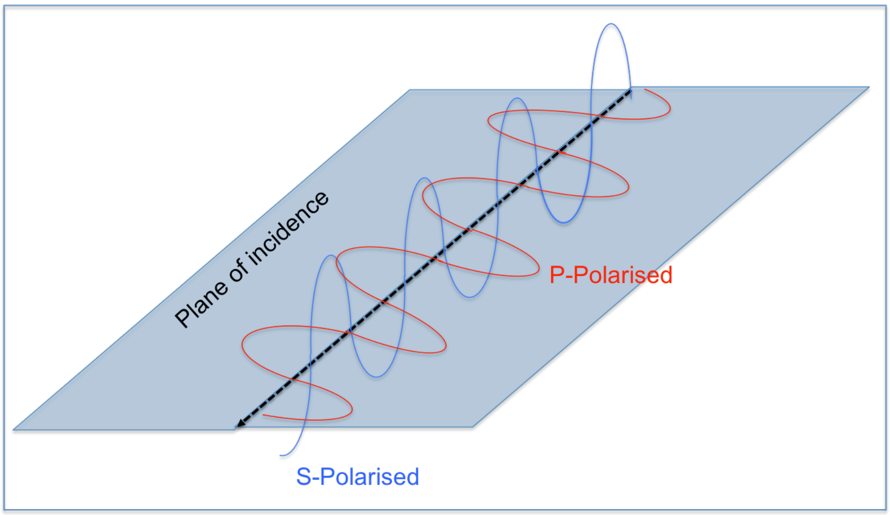


*Diagram showing s and p polarised rays.*

In the MPO catalogue, one will find the polarisation of a ray described in 3 ways; s-POL, p-POL, and Rand-POL. The first two refer to the s or p polarisation states of the ray discussed above, and the third references unpolarised light.

The different polarisation of rays affect the way that they interact with a material, for example ***Brewster's angle*** is the angle at which p-polarised light is perfectly transmitted through the surface in question. The result of this is that when light is incident at Brewster's angle, the partially reflected light will be s-polarised, and the transmitted light will remain both s and p polarised, with a smaller fraction transmitted as s pol. This means that by placing multiple plates at Brewster's angle in a line will eventually result in linear polarisation of both reflected and transmitted. Practically one would have to put a large number of plates in line to achieve this, so it is rarely used nowadays for polarisation.

References:

Handbook of Optical Systems Volume 5, H. Gross (ed.), Wiley-VCH Verlag GmbH & Co KG, 2012, ISBN 978-3-527-40381-3

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