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Optical Physics: Summary Session 7 and 8

Diffraction
When light passes an aperture it's diffracted (spread out) due to its wave properties. Diffraction makes the image of the aperture a bit blurred. The mathematical calculation describing how the aperture influences light can be approximated for different distances behind the aperture.

Grating Equation: $a \sin \theta_m = m\lambda$, where $m = 0, 1, 2, ...$

Fraunhofer approximation is adapted to large distances, i.e. when parallel light is incident on the aperture and then propagates to a screen infinitely far away from the aperture. Observe that a lens images infinity to the focal plane, which can be very useful. The Fraunhofer pattern registered is identical to the Fourier transform of the shape of the aperture. These arrangements are therefore called **Fourier optical arrangements**. The Fraunhofer pattern for some common apertures are given in the book, where the Fraunhofer pattern for a cicular aperture with diameter d is an Airy disc with radius $q_1 = 1,22\frac{R\lambda}{d} = 1,22\frac{f\lambda}{d}$ where R is the distance between aperture and screen and f is the focal length of an optional lens.

The Fresnel approximation is valid for distances close to the aperture or when the incident light is not parallel. The mathematical expressions for this case becomes more complicated than for the case with Fraunhofer diffraction.

A few important things that makes it easier to determine what the pattern from a particular aperture will look like:

- A complicated aperture can be divided into a few apertures, each with a simple shape. The sum of the diffraction patterns from each aperture gives the total diffraction pattern. Observe that small details in the aperture give a large diffraction pattern.
- **Babinet's principle** states that the diffraction pattern is independent of whether the aperture is inverted or not, i.e. the pattern from an opaque screen with a hole is the same as that of a transparent screen with an opaque circle.
- The Fourier transform is translation invariant and the Fraunhofer pattern is therefore insensitive to translation of the aperture.

Coherence
The coherence of a light source is a measure of how long (time coherence/longitudinell coherence) and toward which directions (spatial coherence/transverse coherence) the source emits with the same phase. This is especially important when interference is desired. The two interfering waves must be coherent with each other (observe that two separated light sources are not coherent). If this is the case one obtains interference fringes with a certain **visibility**:

$\mathscr{V} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$

The visibility is 1 for a pattern with $I_{min} = 0$.