PREPARATORY SCHOOL TO THE

Winter College on Optics 2020

Quantum Photonics and Information

OUTLINE OF THE EXPERIMENTS in the DIFFRACTION LABORATORY

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EXPERIMENTS on

1 - DIFFRACTION and FOURIER TRANSFORMS

2 - EVANESCENT WAVES

3 - POLARIZATION, simple tests

Another experiment in the laboratory:

4 - MICHELSON INTERFEROMETER, also including polarization effects, is conducted by Miltcho Danailov, as separately described.

Important note: here we deal with field phenomena, that is amplitude and phase. Our eyes are sensitive to energy, therefore we will never see the "field" we see:

intensity, that is amplitude square

EXPERIMENTS on DIFFRACTION and FOURIER TRANSFORM

We will experience diffraction of HeNe laser radiation, wavelength 632,8 nm, by:

a - wires,

b - slits of different width and

c - circular apertures of different radius

and will make measurements to check the dependence on the aperture radius

We will give interpretation of diffraction in terms of Fourier transform

DIFFRACTION GIVES RISE TO:

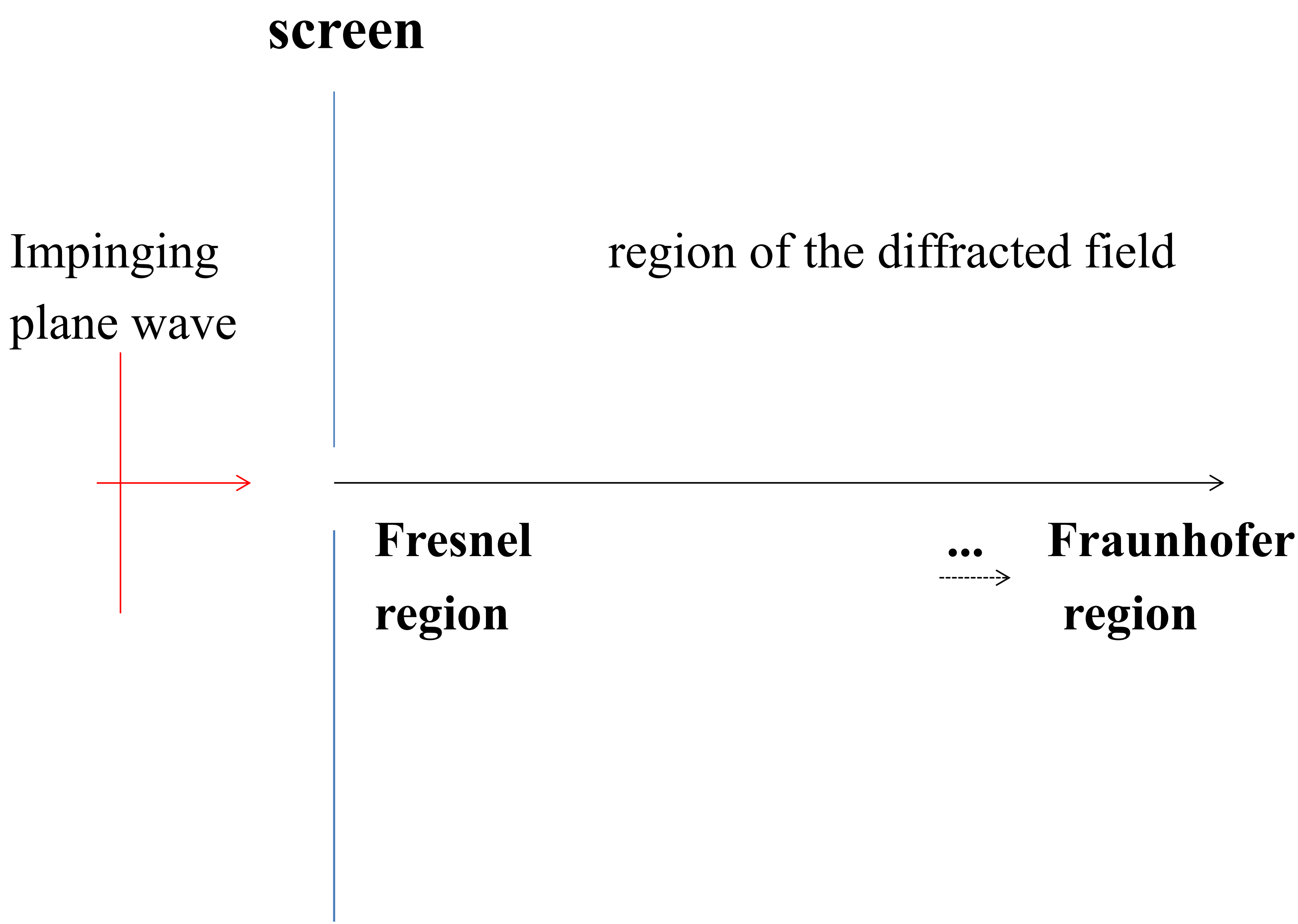
1 - (real) waves propagating in the space after the screen.

On a screen at some distance they give rise to an illumination patterns depending on the distance. Most interest here is on a screen very far, Fraunhofer region.

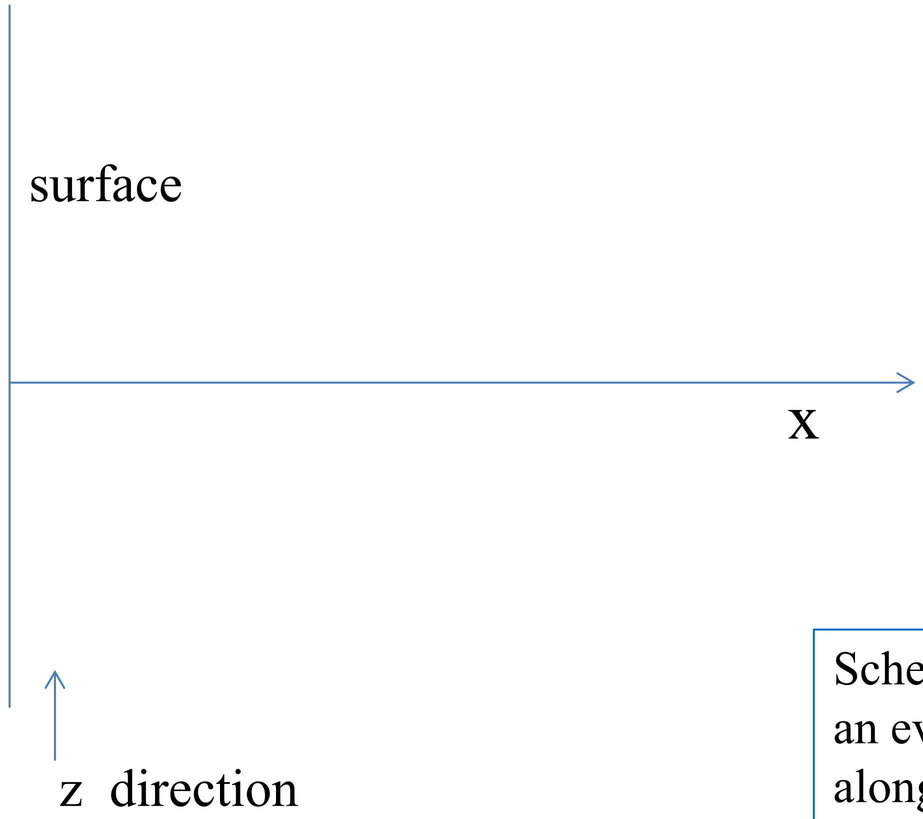
2 - evanescent waves propagating along the screen.

They are also called surface waves. Their amplitude decreases in few wavelengths from the screen and do not propagate in the space. They carry information that is lost and set the diffraction limit to the resolving power of optics instruments

Diffraction by an aperture on a screen



GEOMETRY OF EVANESCENT WAVES



Scheme for the description of an evanescent wave flowing along a surface in z direction and evanescing normally to it.

$$v(P,t) = A \exp(-k\, \alpha_i\, x) \exp[i(k\, \gamma_r\, z - \omega t)]$$

DIFFRACTION EXPERIMENTS

- We will follow the pattern development from Fresnel to Fraunhofer region
- We will check the angular dependence on the aperture width by measuring the width of the intensity patterns in the Fraunhofer region in different cases.
- For the circular opening: considerations on the resolving power of instruments, such as the Telescope, will be made.

FOURIER TRANSFORM

Diffraction operates the Fourier Transform:

the field at infinity is the transform of the field on the aperture

We will check that

FUNCTION	TRANSFORM
1 - **Rect**	**Sinc** = [sin(arg)] /arg
2 - **Circ**	**Airy Function** = [Bessel J_1(arg)] /arg

Remember: **we see the square**.

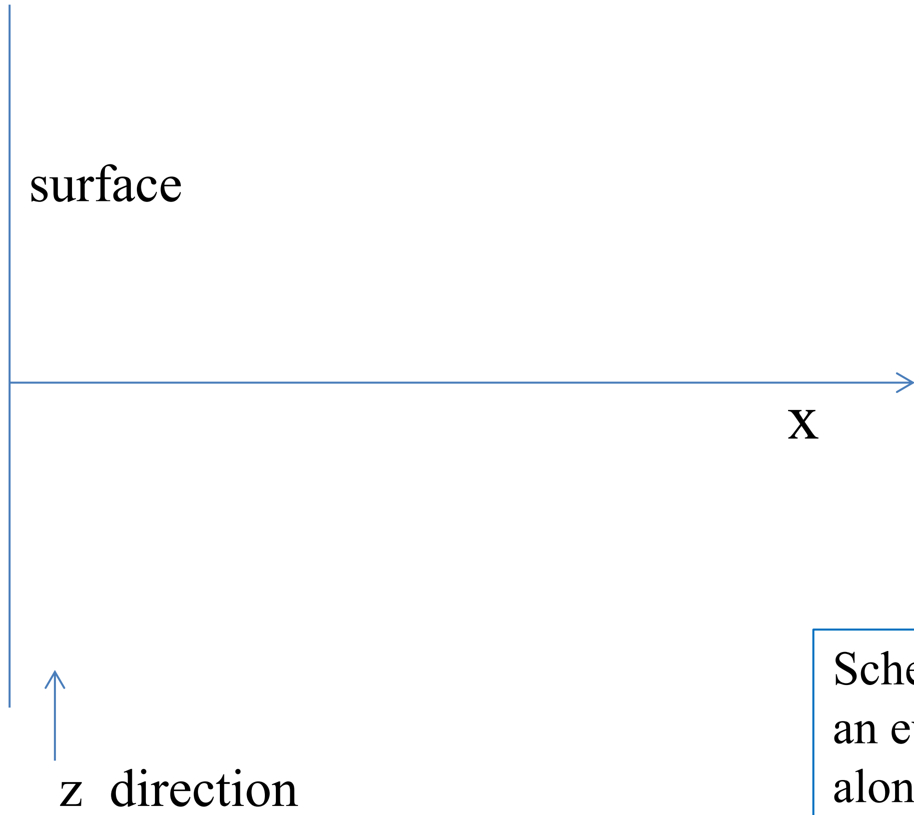
If the aperture is the border of a converging lens, the transform goes in the focal plane. In the **focal plane** the lens operates the **Fourier Transform of the field on its aperture**. This is the basis of the optical elaboration of images, which utilizes the Convolution theorem in the focal plane.

2 - EXPERIMENT on EVANESCENT WAVES

Evanescent waves are waves that propagate, flow, along a surface and "evanesce" at a distance of few wavelengths from the surface, as the amplitude decreases exponentially from the surface. For this reason evanescent waves are also called "**surface waves**", and cannot exist without a surface where they are generated and along which they propagate.

As the equi-amplitude and equi-phase surfaces do not coincide, more precise are orthogonal, sometimes they are denoted as “dissociate” waves.

GEOMETRY OF EVANESCENT WAVES



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amplitude phase

MORE ON EVANESCENT WAVES

In addition to **diffraction**, evanescent waves are present in the phenomenon of **total reflection**, such as in prisms and in fibers. Total reflection allows guided propagation in fibers.

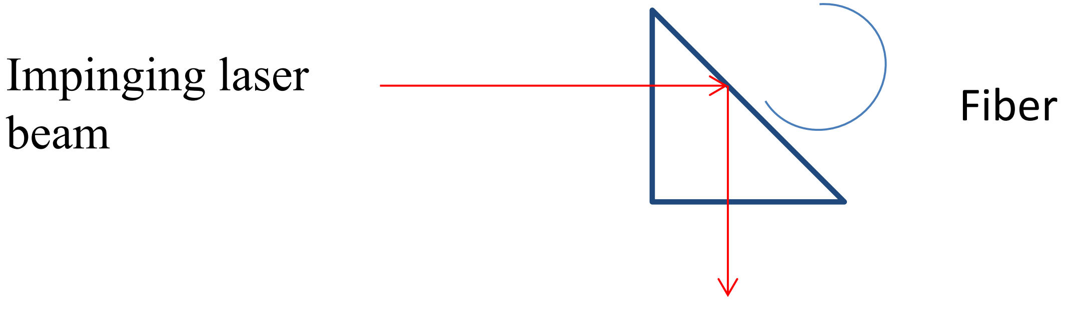
As is well known, when light impinges from a **more refracting** material on the surface separating it from a **less refracting** material at an angle higher than a given limit value, “critical angle”, it is **completely reflected**. No light appears in the second material. However, an evanescent field propagates along the separation surface in the second material. It means that a real field gives rise to an evanescent field. Reciprocity also holds, that is an evanescent field gives rise to a real field.

Evanescent waves are the basis of the kind of microscopy, called near field microscopy, that allows **superresolution**.

EXPERIMENT on EVANESCENT WAVES

The experiment makes use of reciprocity.

An evanescent field is produced on an external surface of a prism by total internal reflection of a laser beam. The evanescent field is collected by a fiber; the field becomes real inside the fiber and propagates. By looking at the fiber end one sees light.



This is the basic set up for coupling between optics elements, such as fiber-fiber or fiber-prism, in measuring devices based on fibers.

SIMPLE DEMONSTRATIONS OF POLARIZATION

By using polaroid plates, some tests will be made of the polarization state of different light sources, such as different lasers, diodes, led.

For instance, by rotating a polarizing plate, one can find if a laser beam is linearly polarized, and also find the polarization direction.

The polarization effect on interference will also be seen in the Michelson interferometry experiment.

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