PREPARATORY SCHOOL TO THE
Winter College on Optics 2017:
Applied Optical Techniques for Bio-Imaging

OUTLINE OF THE EXPERIMENTS in the

DIFFRACTION LABORATORY

ANNA CONSORTINI

UNIVERSITA` DEGLI STUDI DI FIRENZE

anna.consortini@unifi.it

EXPERIMENTS on

1 - DIFFRACTION and FOURIER TRANSFORM

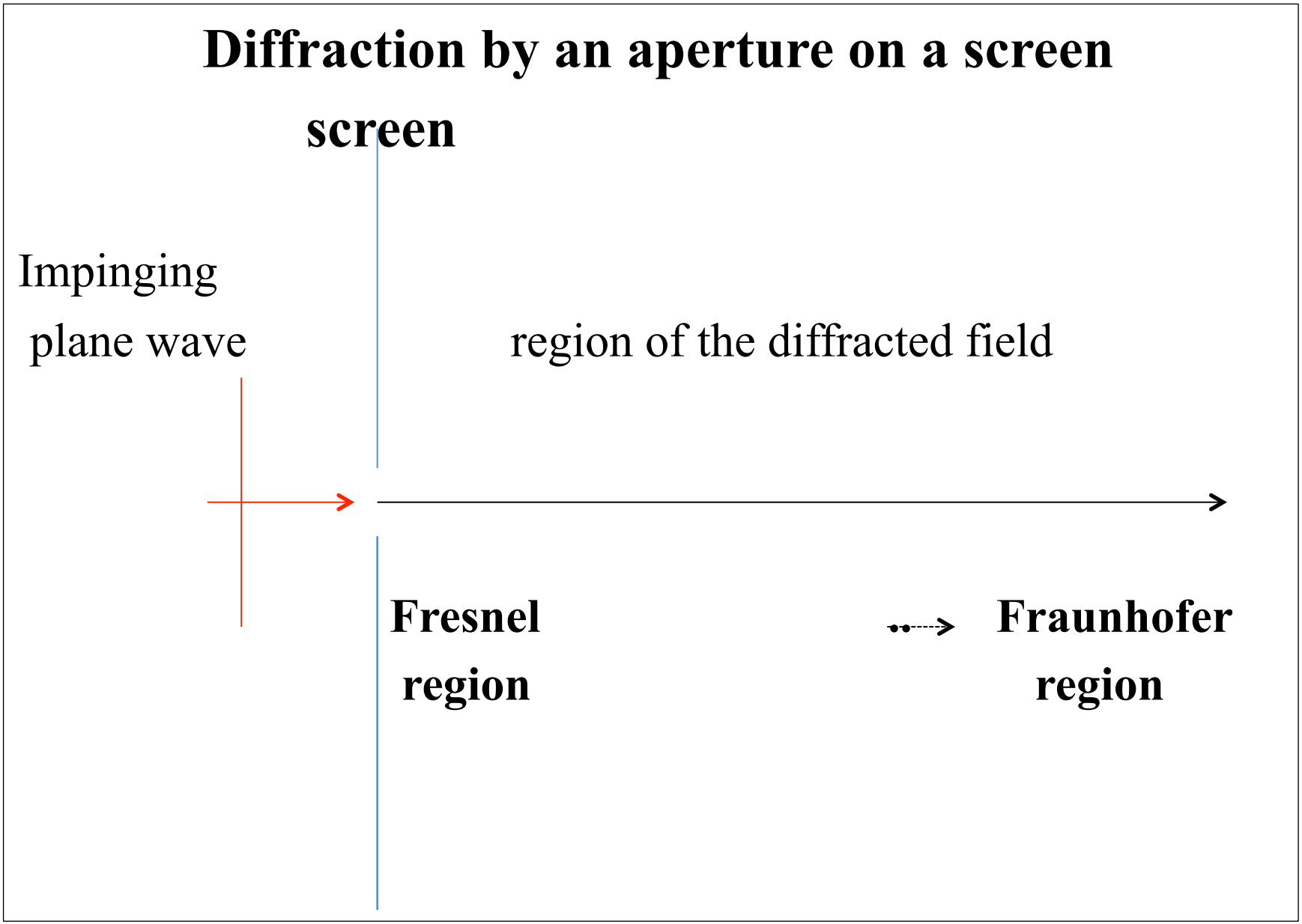
2 - EVANESCENT WAVES

3 - BASIC OF SPECTROSCOPY : DECOMPOSITION OF LIGHT BY DIFFRACTION GRATINGS

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

we see: amplitude square

Diffraction by an aperture on a screen



Here we will experience diffraction of laser radiation, HeNe, wavelength 632,8nm, by

a- wires, by

b- slits of different width and by

c- circular apertures of different radius.

Diffraction also gives rise to evanescent waves.

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, eg. Telescope, will be made.

Microscope deserves some more attention, it is developed in the corresponding Laboratory, Abbe formula.

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**.

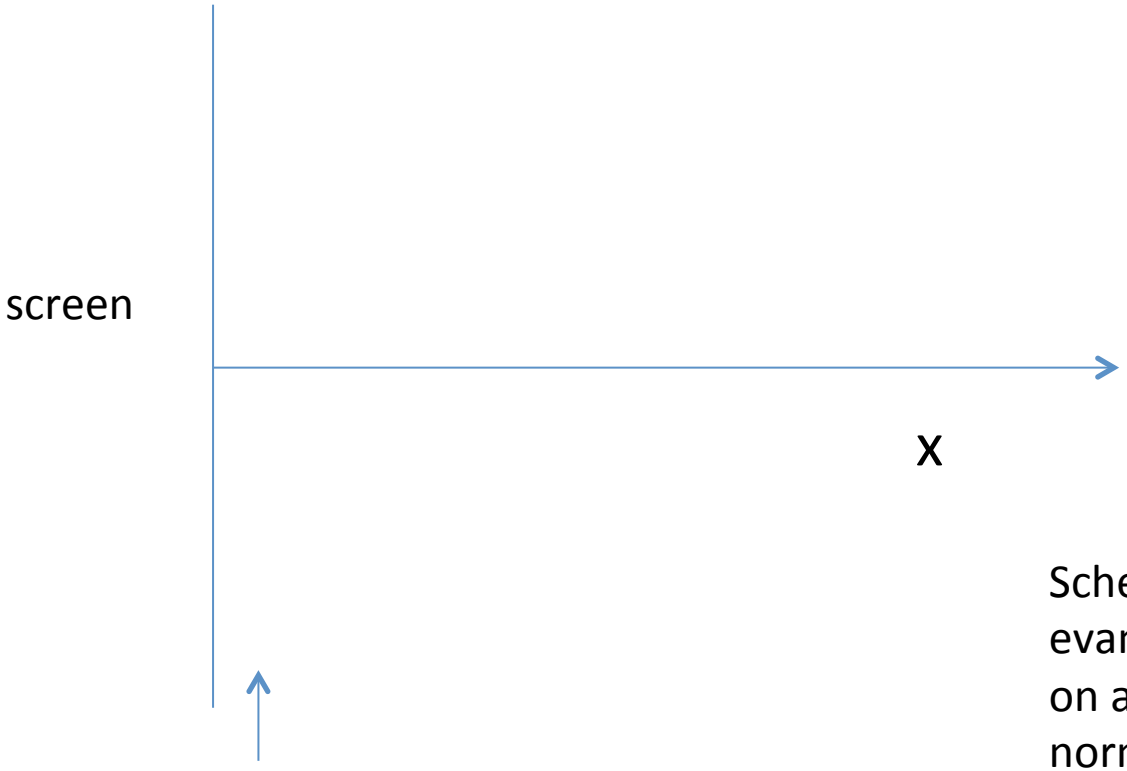
If the aperture is the border of a converging lens, the transform goes in the focal plane. In the focal plane the lens operates the Fourier Transform of the **field** on its the aperture. This is the basis of the optical elaboration of images, which utilizes the Convolution theorem in the focal plane.

2- EXPERIMENT on EVANESCENT WAVES

Evanescent waves, such as those mentioned before, 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.

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

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



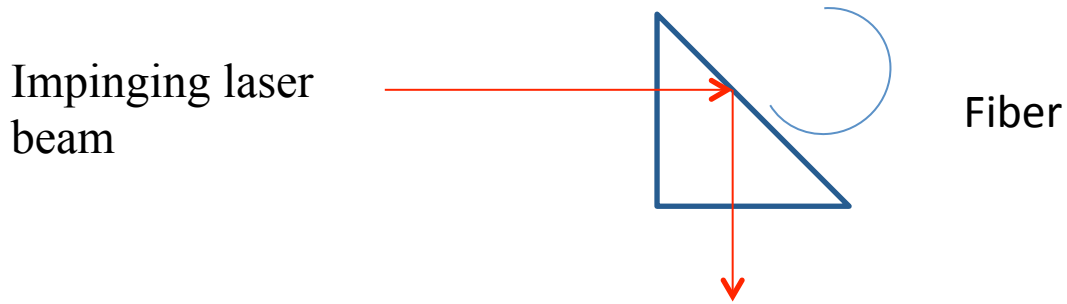
Scheme for description of evanescent wave flowing on a screen and evanescing normally.

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

EXPERIMENT on EVANESCENT WAVES

The experiment makes use of reciprocity.

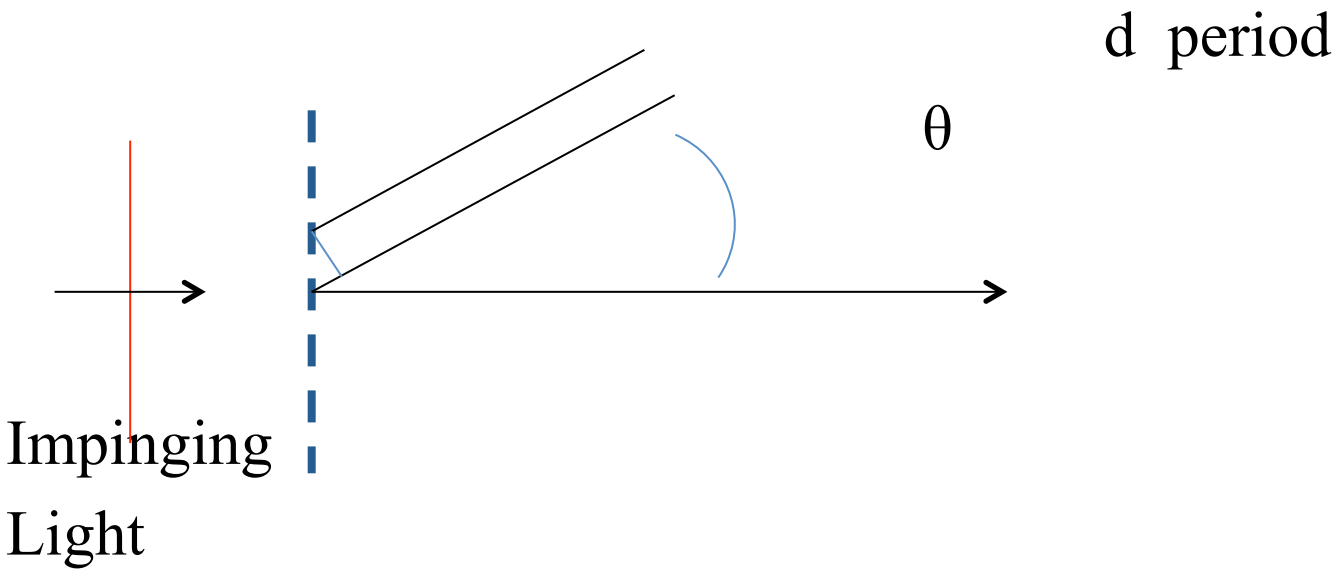
An evanescent field is produced on an external surface of a prism by total internal reflection of a laser beam. The evanescent field is collected by a fiber; the field becomes real inside the fiber and propagates. By looking at the fiber end one sees light.



This is the basic set up for coupling between optics elements, such as fibers, in measuring devices.

3 - BASIC OF SPECTROSCOPY: DECOMPOSITION OF LIGHT BY DIFFRACTION GRATINGS

- Spectroscopy is separation of light from a source in its frequency components. The basic element allowing it is the diffraction grating.



$d \sin \theta = m \lambda$, constructive interference

EXPERIMENTS

By use of linear gratings of different periods (100, 300, and 600 and 1000 lines/mm) decomposition will be shown of radiation from different sources including lasers and leds. A number of orders will be seen.

In particular cases the relationship between the wavelengths of two laser, green and red, will be checked by measuring the diffraction angles.

Examples will be also seen of spectra produced by a two-dimensional grating.

Acknowledgements

Thanks are due to:

- the Open Lab of the University of Florence, for supplying a number of diffraction gratings,
- the Elettra Sincrotrone, Trieste, for supplying a laser and some optical components.

The laboratory experiments are organized by Miltcho Danailov, Imrana Asharaf and Anna Consortini.