Exam

- Two lenses (L1 with focal length f1, L2 with f2, f1<f2). Object is a single dot in the front focal plane of the first lens and it is not on the optical axis. Draw the rays! [See other posts in the biomedical engineering @ Tuwien facebook group!)
- What kind of wave is there between the lenses? Plane wave. What happens if we introduce an aperture between the lenses? Diffraction pattern. What does that look like? Aery function. Sketch the Aery function and describe it briefly.
- What is the resolution of a microscope? d = 1.22 lambda/ (2 NA) [This is the only exam-relevant formula.] Explain this formula!
- What happens when you open the aforementioned aperture? What happens with the Aery function when you use infinitely large lenses?
- How can you achieve super resolution? Describe one method (e.g. STED). Some follow up questions about this.

Exam 26.02.2021

First question he asks to anybody: construct the image of an object in a system of two lenses, the object is in the front focus of the first lens.

From there I had to discuss about Airy Disk and diffraction in general.

As a second question, since I am studying Physics, he asked me Heisenberg microscope: nothing by memory, he wants you to think and be able to menage the discussion.

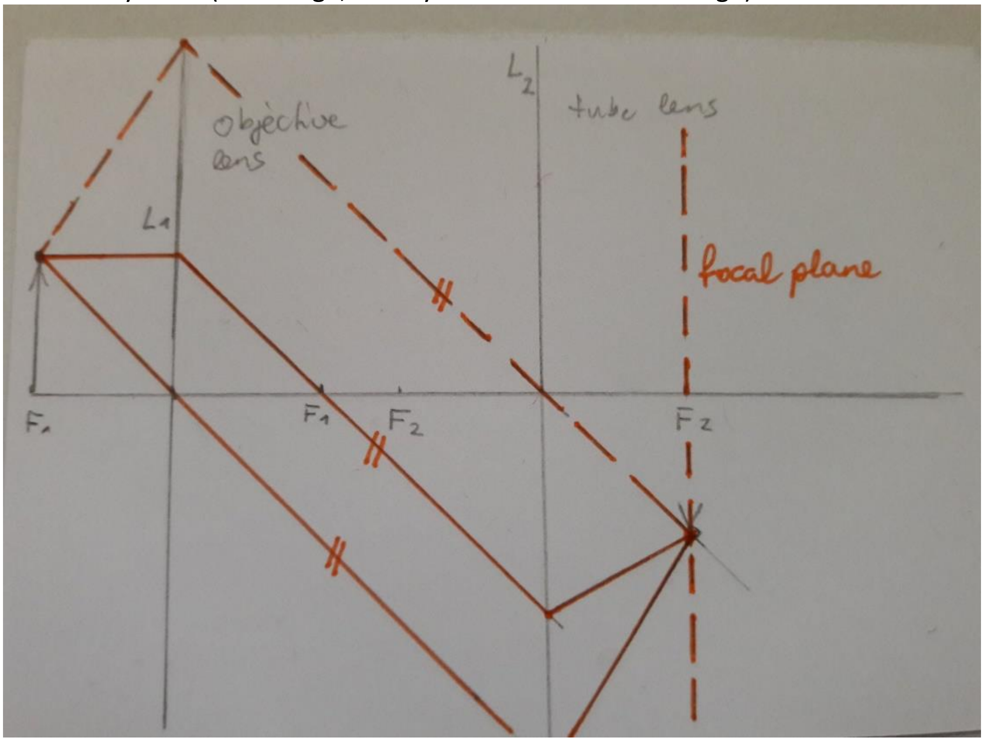
Exam Febuar 2019
the first question was the same as for everyone (he said it in the lectures).

My second question was explaining the airy function and its origin sketching it in the same page giving the important formulas and some other details on the fly.

Third question was to explain a technique of my choice from the second part of the course, here prof Schütz got kinda detailed again and you need to recall his words in the lecture or to think clearly really fast with intuition to answer his logic questions.

Exam

First question and according to him the one question everyone gets: Draw the ray paths in the given two lens system. (See image, what you have to draw is orange)



What's tricky about this one, is that you have to know that you need to construct a third ray, parallel to the others which is also the central ray for the second lens and that the image will be somewhere on the focal plane. --> Intersect central ray and focal plane, the other rays will also hit that point

Then: What are the depicted lenses called (see image), how is the point imaged --> Airy-Disc, draw the cross section of the airy disc, how will it change with bigger aperture (become narrower), how is an aperture imaged (Fourier transform), resolution limit formula (what does d stand for --> distance to first min), explain one sub-diffraction microscopy method.

Exam July 2016

Geometric optics, drawing: Two lenses in a row, in the focus of the first one is an object. Construct the image, it is useful that you know that the region between first and second lens contains only "parallel beams" and why this is useful.

What do we really see at the image plane? -> Fraunhofer-Diffraction, PSF, Airy-Function, …

If we would have an infinite big lens which would not cut off parts of the Fourier-Spectrum, would the Airy-Function converge to a point? No -> Heisenberg-Microscope, Uncertainty-Principle, …

I could choose to explain one of the Super Resolution Microscopy techniques, I choose the STED-Microscopy and how we can overcome the traditional resolution limit by this method.

<u>What you meant with heisenberg microscope? Why the psf doesnt converge to a point?:</u>
The Heisenberg microscope is a kind of thought experiment based on the Heisenberg uncertainty principle which states: $\Delta x * \Delta p >= \hbar/2$, where Δx represents the uncertainty in position, while Δp represents the uncertainty in momentum of photons emitted by an object. Transform -> $\Delta p >=$

$\hbar/(2\Delta x)$ -> you see, that for smaller and smaller Δx (-> better resolution), you get higher and higher uncertainty in Δp.
However, the maximal momentum of a particle is dependent, and thus limited, by the energy source of your photons.
Prof. Schütz was happy with this kind of explanation, and some drawings showing photons with initial momentum p going through a slit of size Δx, after which the uncertainty of Δp_y depend on the slit size Δx proportional to the Heisenberg uncertainty principle ... etc.
Since p is limited, Δp_y is limited too, and thus the size of a lens which is actually hit by photons etc.