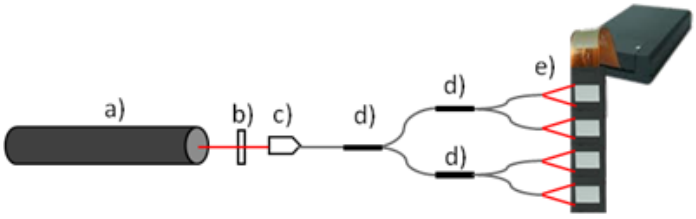
Spatial phase modulation of laser light beams, in conjunction with methods of computer holography, theoretically enables the realization of any given optical function. However, the range of possibilities is limited by a finite number of active dots (pixels) of liquid crystal modulators. It is therefore extremely desirable to combine multiple modulators in order to combine the active regions and to sum the active pixels. In this project we will check if this is possible with the use of synthetic aperture.

The concept of the synthetic aperture is commonly used in the field of radar and microwave band in order to increase the effective aperture of the detector by its lateral displacement over the scanned target. The scientific goal of the project is to demonstrate the applicability of the concept of synthetic aperture with respect to synthetic (computer) holography. In this project we shall adapt idea from radar band in an opposite way - not to detect signals with increased details, but to shape the impinging laser beams into diffracted light fields with increased effective aperture.

To achieve that we should combine a number of modulators, and synchronizing them, so that from an optical point of view, they constitute a common surface. On that surface there occurs a controlled coherent phase modulation resulting in a diffraction of the incident laser beam on a very large surface. Of course, such created common space will be fragmented due to the non-zero spacing between the active areas of the modulators (e.g. the borders of the enclosures). Nevertheless, by using the fundamental properties of holography, i.e. the possibility of reconstructing the whole of the recorded signal from any part of the hologram, it will be possible to omit the influence of "dead areas" on the reconstructed signal.

The key issue of the project will be the relative placement and fine adjustment of the modulators (pixel size is 8µm x 8µm) and their internal compensation performed in order to obtain a flat wavefront characteristics of the light field reflected in the first diffraction order. It means the necessity to perform fine adjustment of individual settings of the modulators and the proper selection of the parameters of the corrective function. Those corrective functions will be the coherent combinations of saw-tooth phase gratings and function of the divergent lens constructed by iterative selection of appropriate coefficients.
In addition it must be ensured correct lighting system. Moreover, the entire set must be illuminated with the same, coherent wave front which, on the other hand, should not excessively illuminate the areas located between the active surfaces of the modulators, as this shall lower the light intensity. The solution may be either appropriate beam forming in the optical system and in the fiber-based system, characterized by smaller size and much easier configuration. The proposed conceptual diagram is located in the following illustration.



The beam from the He- Ne laser (a) is inserted into a single- modal fiber after passing through the half-waveplate (b) by means of a fiber collimator (c). Then, by using a directional coupler (d) the light is separated into two secondary optical fibers and then into four fibers, whose tips (e) are treated as quasi- point light sources illuminating the four used SLM modulators. The important advantage of this solution is the flexibility in the setting of modulators, which shall allow us to examine the resolution of the images at different configurations of component SLMs (in the above figure an interesting parallel setting is shown).

The positive outcome of the project will in future open the possibility of applying for an R&D research project aimed at the exploration of the practical implementations of the ultra-large-area holographic beam forming, for example in the field of optical trapping. Today it is the main industrial application of computer holography. A critical parameter in this field of science and technology, determining the potential applicability, is the size of the light spot used for manipulation of micro - objects in the microscopic slide. The numerical aperture of the active area of the light modulator directly determines the size of the mentioned light spot. Its role is also the shaping and positioning of one or multiple spots in the volume of the examined medium. In addition, the complexity of the 3-D definition of the shape of the spots (especially in the case of numerous spots) is strongly related to the number of pixels of the modulator. For these reasons, the application of the concept of synthetic aperture will allow for a much better performance, which may be opened for new research fields of computer holography.

Another attractive target for future applied grants based on this project will be the development of holographic projection images with ultra-high resolution (i.e. with the very high number of displayed image points). Many-fold increased resolution will be achieved by a coherent setting of a large synthetic aperture modulator with a gigantic number of pixels, composed of the light modulators of ordinary resolutions and much lower price. These are extremely desirable characteristics from the point of view of the huge display industry, which in the next decade is supposed to spread computer displays, TVs and home/cinema projectors with image resolutions of 2000 lines and 4000 lines. It is essential that with such a modular compilation of modulators in any shape and size the final resolution of synthetic-aperture devices in practice seems to be unlimited (e.g. 8000 lines or more). Besides, it will be possible to construct modulators not flat, but with a spherical or cylindrical shape, which is important in the process of adjusting the optical system to modern sources of light, such as high-power direct emission lasers, fiber sources, etc.

The above very attractive possibilities for future applications, however, require in the first place a thorough knowledge of a fundamental way of implementation and limitations given by the synthetic aperture concept to visible light, as applied to computer holography - this is the main objective of this project.