Practical example: diffraction

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Lecture 11

According to Huygens’ principle, every point on the mask is a secondary source. Thus, the electric field magnitude at a target is expressed through a known electric field at a mask.

\[ E_{\text{target}}(\vec{r}) \sim \int \int_{\text{mask}} dx' \, dy' \frac{E_{\text{mask}}(x', y')}{|\vec{r} - \vec{r}'|} e^{ik|\vec{r} - \vec{r}'|} \]

We assumed that both the mask and the target are parallel to the \( x - y \) plane and that \( \vec{r} - \vec{r}' \) is mostly parallel to \( z \) axis. Here

- \( \vec{r} = (x, y, z) \) is the radius vector pointing to the target point,
- \( \vec{r}' = (x', y', z') \) is the radius vector pointing to the mask/source,
- \( k = \frac{2\pi}{\lambda} \) is the magnitude of \( k \)-vector.

**Diffraction approximation via sum**

\[ E_{\text{target}}(\vec{r}) \sim \sum_i \sum_k \Delta x' \Delta y' E_{\text{mask}}(x'_i, y'_k) e^{ik|\vec{r} - \vec{r}'|} \]

Here

- \( \vec{r} = x, y, z \)
- \( \vec{r}' = x'_i, y'_k, z' \)
- \( k' = \frac{2\pi}{\lambda} \)

It is important that the integrated function does not oscillate wildly from one sample point to another sample point. So, we need \( \Delta x' \) and \( \Delta y' \ll \sqrt{L} \), where \( L \) is distance between the mask and the target.

**Sample of diffraction**

Let’s consider a diffraction of light on a mask shown below.

- resolution 1386 × 600 pixels
- physical size 2.8 × 1.2 cm
- distance to the target 1.1 m

- resolution 693 × 200 pixels,
- physical size 3.0 × 1.4 cm
- wavelength \( \lambda = 670 \) nm

Calculation time 6 and half hours at the 6 core AMD computer