Practical example: diffraction

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Lecture 11

Diffraction

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.

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

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 is the radius vector pointing to the mask/source,
- $k = \frac{2\pi}{\lambda}$ is the magnitude of k-vector.

Diffraction approximation via sum

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

Here

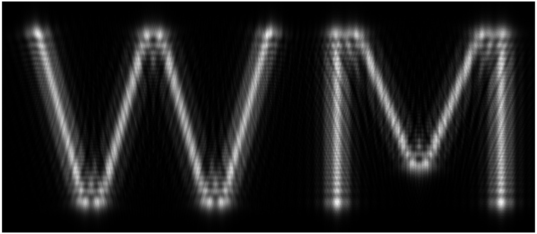
$$\begin{aligned} \vec{r} &= x, y, z \\ \vec{r}' &= x'_i, y'_k, z' \\ \vec{k} &= \frac{2\pi}{\lambda} \end{aligned}$$

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 $\Delta y' \ll \sqrt{L\lambda}$, 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