Practical example: diffraction

EugeniE. Mikhailov

The College of William & Mary

Lecture 09
Diffraction

According to Huygens’ principle, every point on the mask is a secondary source

\[ E_t(\vec{r}) = \int \int_{\text{mask}} dx' dy' \frac{E(x', y')}{{4\pi|\vec{r} - \vec{r}'|}} e^{i\vec{k}(\vec{r} - \vec{r}')} \]

Here

\[ \vec{r} = x, y, z \]
\[ \vec{r}' = x', y', z' \]
\[ \vec{k} = \frac{2\pi}{\lambda} \]
Diffraction approximation

\[ E_t(\vec{r}) = \sum_i \sum_k \Delta x' \Delta y' \frac{E(x'_i, y'_k)}{4\pi |\vec{r} - \vec{r}'|} e^{i\vec{k}(\vec{r} - \vec{r}')} \]

Here

\[ \vec{r} = x, y, z \]
\[ \vec{r}' = x'_i, y'_k, z' \]
\[ \vec{k} = \frac{2\pi}{\lambda} \]

It is important that integrated function does not oscillate wildly from sample point to sample point. So we need \( \Delta x' \) and \( \Delta y' \ll \sqrt{L\lambda} \), where \( L \) is distance between mask and 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
  \( \lambda = 670 \text{ nm} \)

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