Moving amplitude grating as a time lens for a new UCN source

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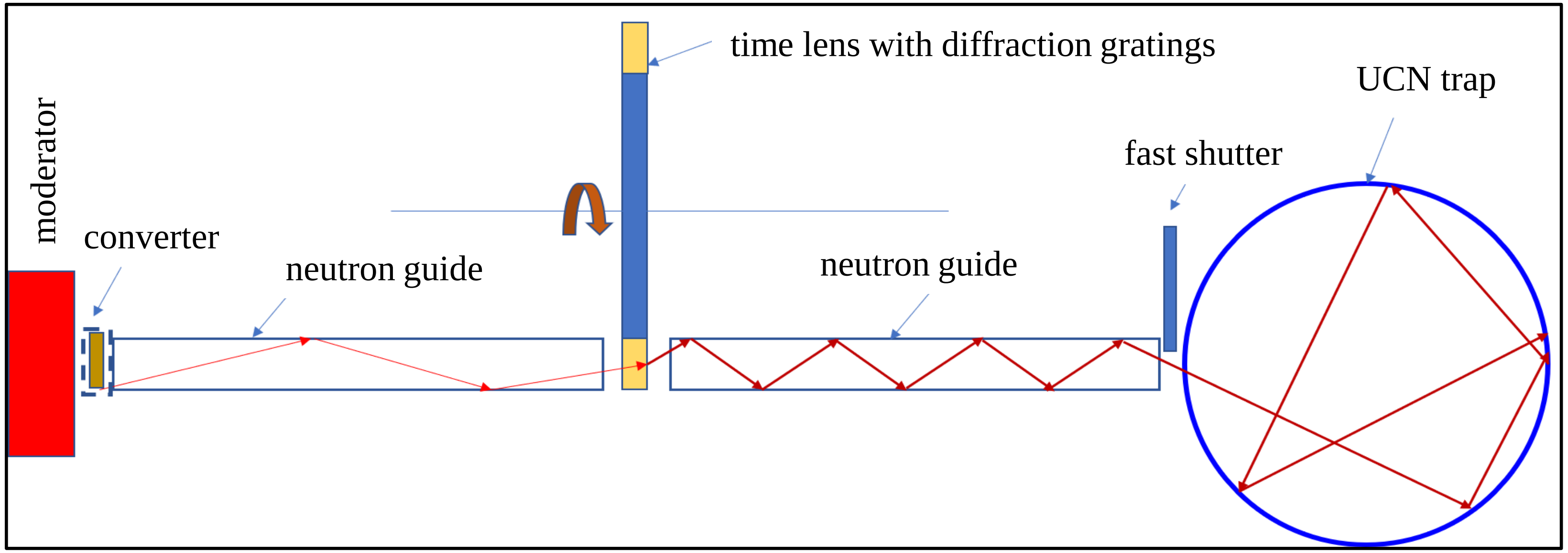
A new UCN source on a periodic pulsed reactor

“On the possibility of creating a UCN source on a pulsed reactor” at ISINN – 28 by German Kulin



Scheme of the UCN source

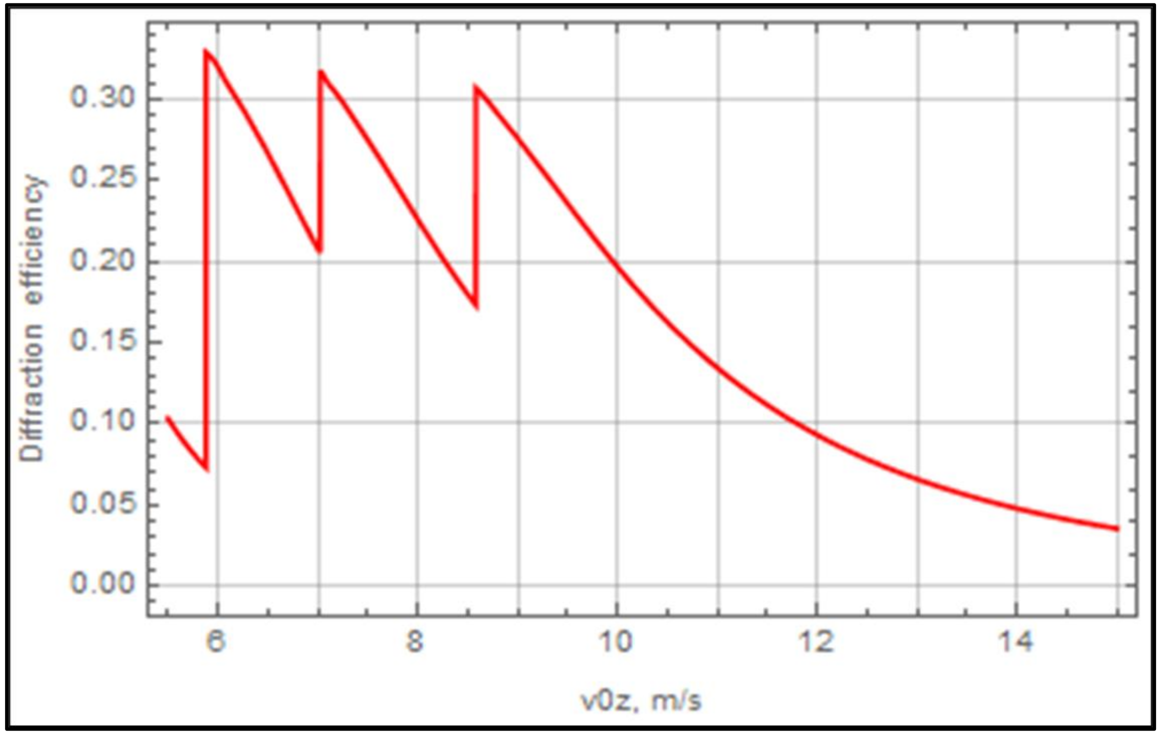
[1] *Frank A. I., Kulin G. V., Rebrova N. V. and Zakharov M. A.* JINR Preprint P3-2021-22. Dubna, 2021.

[2] *Frank A. I. and Gähler R.* Time focusing of neutrons // Phys. At. Nucl. 2000. V. 63. P. 545.

[3] *Shapiro F. L.*, EChAYa, 1971. V. 2. P. 975.

Phase diffraction grating

Total transport efficiency mainly depends on the diffraction efficiency of the time lens

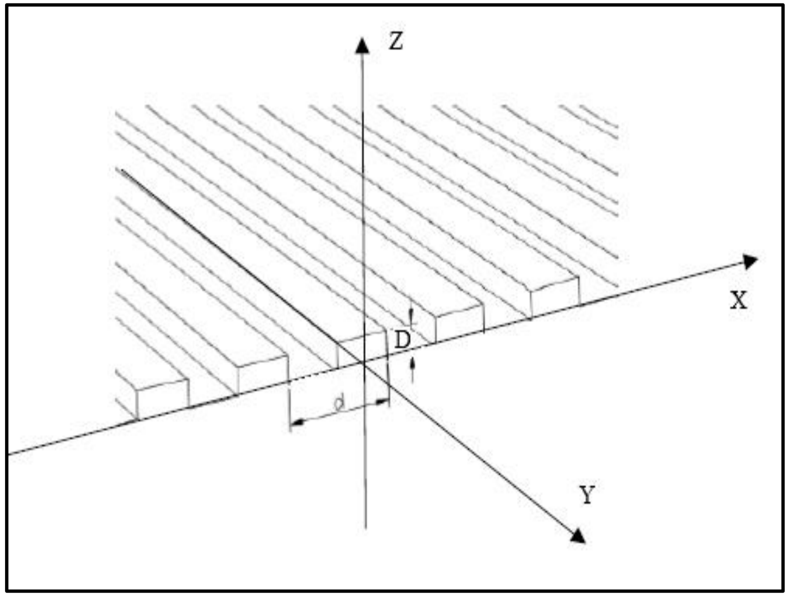


The diffraction efficiency of the phase moving grating

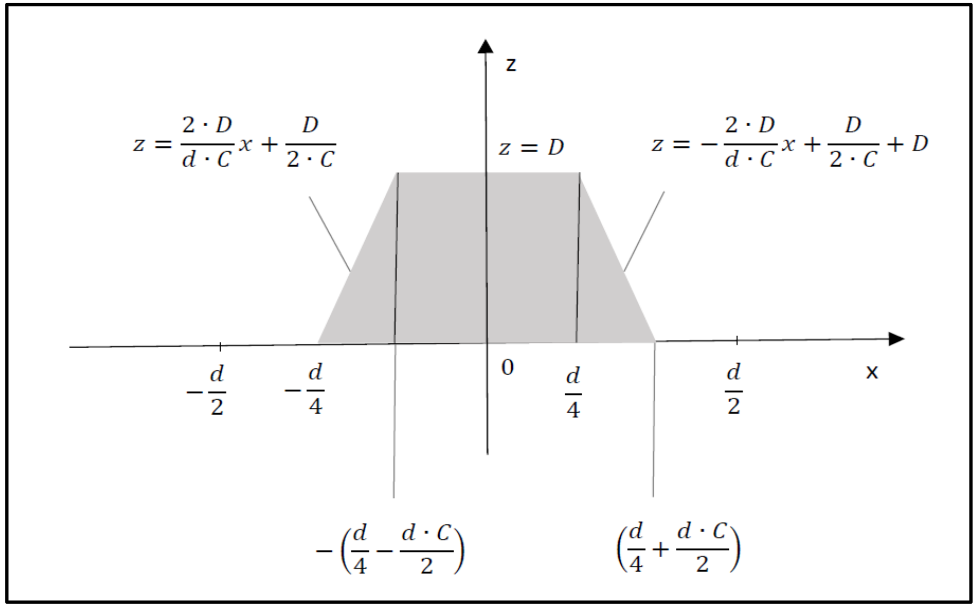
- Problem: The diffraction efficiency of the time lens decreases with increasing neutron energy.
- Solution: To use an amplitude absorbing diffraction grating for high neutron velocities (energies).

Calculation of the diffraction orders intensities at UCNs diffraction by a moving amplitude grating

Orientation of the grating in space



Profile of neutron amplitude transmittance in *z* direction



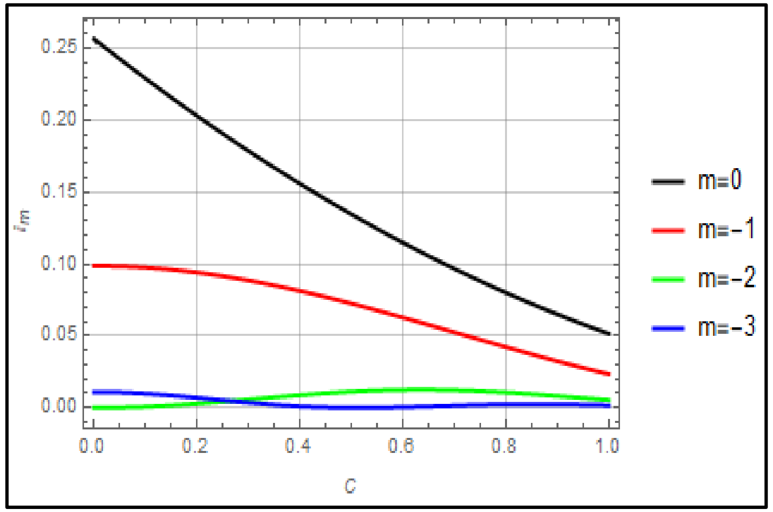
Intensities of the diffracted neutron waves:

$$I_m = |a_m|^2, \qquad \text{where} \quad a_m = \frac{1}{d}\int_0^d t(x)\exp(-img_0x)\,dx$$

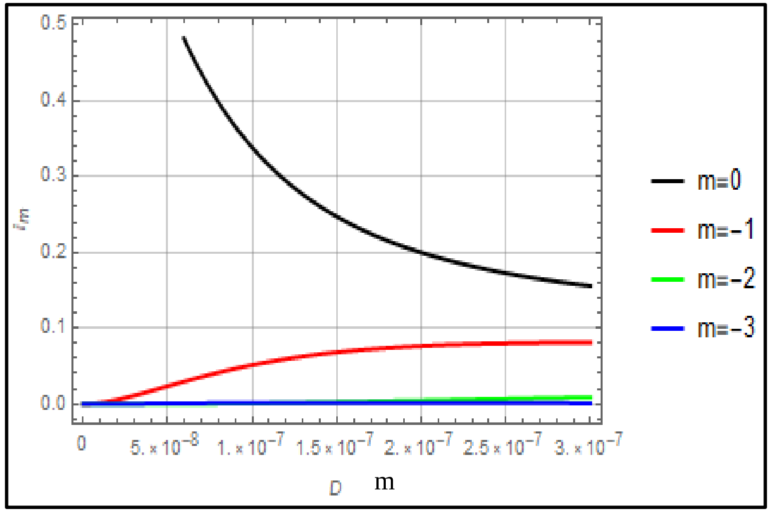
$t(x) = e^{-\gamma(x)} \cdot e^{i\varphi(x)}$ — Transmission function

$\varphi(x)$ – phase shift, $\gamma(x) = \frac{D(x)}{\mu}$, where μ – absorption length, $D(x)$ - effective thickness

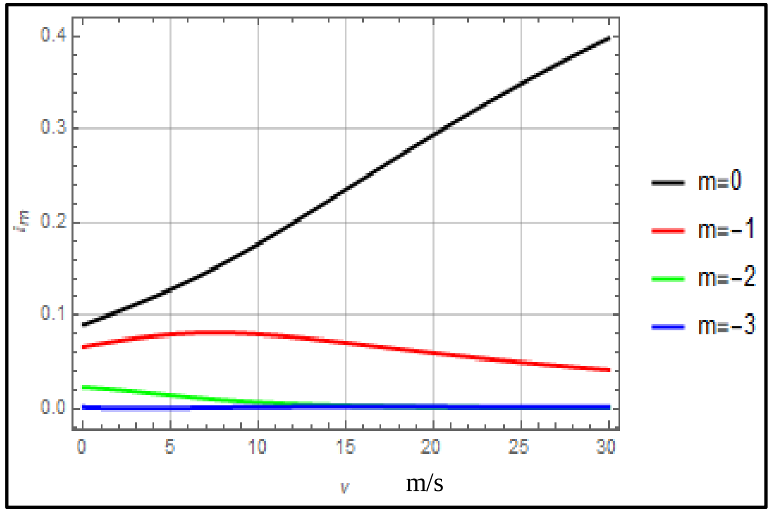
Diffraction efficiency of the amplitude gratings with boron – 10



The intensity of the diffraction orders as a function of C - parameter (depth of groove is 0.3 μm, velocity of neutrons falling on the grating is 8 m/s)

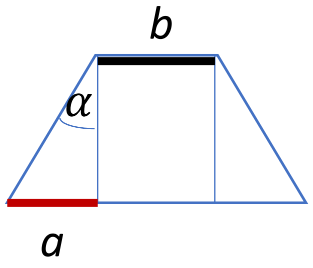


The intensity of the diffraction orders as a function of the groove's depth (fixed incident neutron's velocity, fixed modulation frequency).



The intensity of the diffraction orders as a function of the incident neutron's velocity at a fixed groove's depth and a fixed modulation frequency.

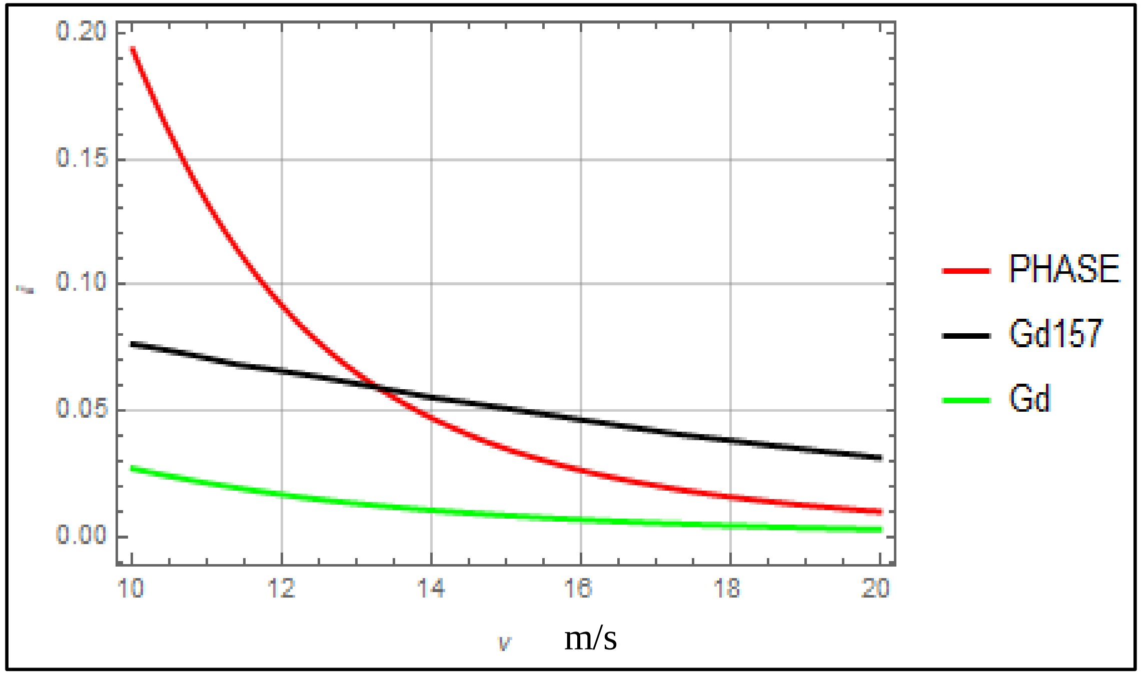
A dimensionless parameter $C = \frac{2D}{d}\frac{(V_{gr}-v_{0x})}{v_{0z}}$



$$C = \frac{a}{b} = \frac{D \cdot \tan\alpha}{d/2}, \quad \tan\alpha = \frac{(V_{gr} - v_{0x})}{v_{0z}}$$

Diffraction efficiency of the amplitude grating

The intensity of the -1 diffraction order as a function of the neutron velocity incident on the moving grating.



In the case of using gadolinium - 157 for neutrons with velocities higher than 14 m/sec, there is a gain in diffraction efficiency of 2 - 3 times.

The transition to the amplitude grating for neutrons with high velocities — ?