# **NON-STATIONARY TRANSFORMATION OF NEUTRON ENERGY AT DIFFRACTION ON A MOVING GRATING AND SAW**

## MOVING GRATING

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#### INVESTIGATION

#### additional variance σ*m* for the peaks of the corre- $\Delta$ CE ACOLISTIC WAVE (SAW)  $\square$  $\begin{picture}(180,190) \put(0,0){\line(1,0){10}} \put(1,0){\line(1,0){10}} \put(1$

 Effect of neutron energy change in diffraction by a moving grating was predicted in Ref. [1]. It was shown that when the amplitude or phase grating moves across the neutron beam the grating can act as a quantum modulator of the neutron wave transforming the spectrum of transmitted neutrons. As a result the spectrum is characterized by a discrete set of energies. Firstly phenomenon was demonstrated in experiment [2] using phase diffraction grating.

For a more rigorous description of the phenomenon, taking into account the threedimensional structure of the moving grating, a variant of the multi-wave dynamic diffraction theory was developed [3]. To compare predictions of this theory, the spectra of ultracold neutrons appearing due to neutron diffraction by a moving grating were measured using TOF Fourier spectrometry [4,5]. KULIN et al.

Firaction from moving gratings with two grooves denth (a) 0.14 um and (b) 0.22 um diffraction from moving gratings with two grooves depth (a) 0.14 μm and (b) 0.22 μm Comparison of the experimental (red solid lines) and calculated (blue dashed lines) spectra for the UCN

Discrete UCN spectra, which arise as a result of

SAW arise due to periodical oscillation of the near-surface layer of matter that moves with alternative velocity and acceleration. For the typical values of frequency and amplitude of the ic waye this accoleration reaches yall me wave this acceleration reaches value  $\frac{1}{2}$ ultrasonic wave this acceleration reaches values of the order of 10<sup>7</sup>g. The validity of the concept of the effective potential of matter in the case of such large accelerations, is not obvious a priori.

 $T_{\rm tot}$  measurement results are compared with the compared with  $T_{\rm tot}$ experiment [To] performed at the an Munich) we used a YZ-cut of a  $\mathsf{Linbo}_3$  crystal. On its surface two interdigital transducers (IDT) enosed to excite travelling or standing different filter interference filters were the second were used as  $\frac{d}{dt}$  $\alpha$  dispersive  $\beta = \beta \hat{A}$  NRFX reflectom In the experiment [10] performed at the angle dispersive ( $\lambda$ =4.3Å) NREX reflectometer (MLZ,  $i$ gves with a frequency of 60 MHz were disposed to excite travelling or standing waves with a frequency of <mark>69 MHz.</mark>



### APPLICATION

 Possibility to transform the neutron energy spectrum by diffraction on moving grating allowed to perform neutron focusing in time [6,7]. An aperiodic moving grating was used as a neutron time lens.



The nonstationary phenomenon of neutron diffraction by a moving grating has found its application in the experiments testing the weak equivalence principle for *nound its application in the experiments testing the weak equivalence principle for*<br>the neutron [8] The idea was to compare energy  $m_g g_n H$  with energy transferred to neutron ħΩ nents testing the weak equivalence p was to compare ener<u>y</u> <sup>311</sup> acceleration, and *H* is the difference in height between the traction by a moving o measurements was  $15-20.$ of the grating in the investigated regions were 4.25(1) and <sup>343</sup> m a H with energy tra frigger invier energy ad groove is not exactly rectangular and the groove tapers with <sup>347</sup>

10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 1,0  $1,5$ 2,0 2,5 3,0 Count rate (c/sec) **Distance betwee the filter** •  $f = 105 Hz$ Two FPIs with variable distance between them Detecto *g*  $E_{0}$ H  $\hbar\Omega$   $\int$   $\hbar\Delta\Omega$  $\Delta H$  $\frac{g^{44}n}{2}$  = (1.8 ± 2.1)  $\cdot$  10<sup>-3</sup>  $\mathbf{m}_i\mathbf{g}$  $\mathbf{m}_a$ a  $1 - \frac{m_g m_n}{\sigma} = (1.8 \pm 2.1) \cdot 10^{-3}$ **Result:** Result:  $\frac{1}{2}$  to a half period. The angular period of the angular period. The angular period of the angular period of the angular period of the angular period of the angular period. The angular period of the angular period of <sup>325</sup> structure is exactly known to be α = 2π*/N* with *N* = 94 500.  $\overline{12}$  and  $\overline{12}$  and  $\overline{12}$  $\frac{1}{2}$  and  $\frac{1}{2}$   $\frac{1}{2$  $328$  passing through the neighboring elements of the grating. The grating elements of the grating. The grating elements of the grating elements of the grating elements of the grating. The grating elements of the grating  $\frac{1}{2}$  and  $\frac{1}{2}$   $\frac{1}{2}$  $\frac{1}{3}$  The gradient using  $\frac{1}{3}$  The gradient using an atomic force micro- $\frac{1}{3}$  score  $\frac{1}{3}$  score  $\frac{1}{3}$  score different at different at different at different at different at  $\frac{1}{3}$  $3$ 332 distances from the center were scanned. The image of one of o  $\frac{33}{2}$  these fragments is shown in Fig. 6. Each of the two fragments is shown in Fig. 6. Each of the two fragments is  $\frac{1}{2}$  $\mathbf{3}$  was investigated in four cross sections. The profile in each  $\mathbf{3}$  $\overline{a}$  as  $\overline{b}$  cross section was plotted for subsequent analysis as that shown analysis as that shown analysis as that shown analysis as the shown analysis as the shown analysis as the shown analysis as the shown an <sup>336</sup> in Figs. 7 and 8. The following parameters were measured: 0QX Chilton, U.K. FIG. 7. Two-dimensional image of the grating fragment and the line showing how the cross section was done for the subsequent

on diffraction on a running ways is an essentially non-stationary process result ening. In view of the radial orientation of grooms of groo ogy makes it possible to study this ph Neutron diffraction on a running wave is an essentially non-stationary process resulting in transfer of energy  $E = n\hbar\Omega$  to the neutron. Here  $\Omega$  is the wave frequency and n is an integer. The first, and until recently, only, experiment on the observation of neutron diffraction by a traveling SAW was carried out in the 1980's [9]. The significant progress achieved in neutron paranon with bottor accuracy technology makes it possible to study this phenomenon with better accuracy.







To excite travelling wave a high-frequency electrical signal was applied to one or to another IDT. To excite a







The experimental results are mostly consistent with theoretical predictions. The results obtained for diffraction by a standing wave are in complete agreement with the concept of it as a superposition of two traveling waves.



A clear demonstration of the nonstationary quantum effect. Energy transferred to neutron was varied from ±145 to ±485 neV. The acceleration of the periodically oscillating near- surface layer of matter reaches value of 5×108 m/s2 !!!









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