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

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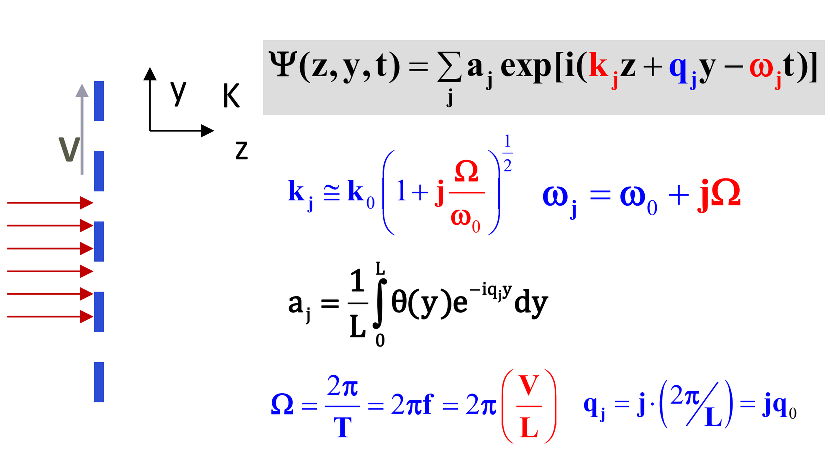
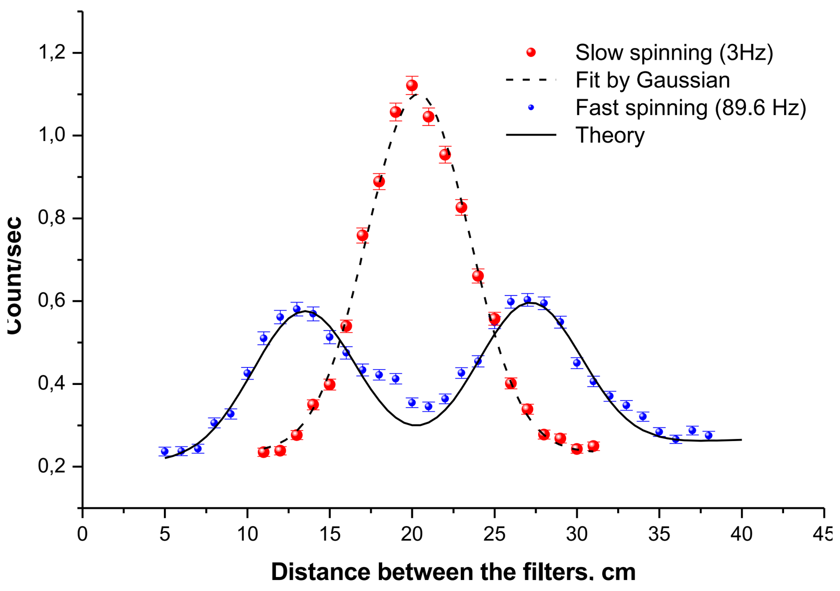
MOVING GRATING

INVESTIGATION

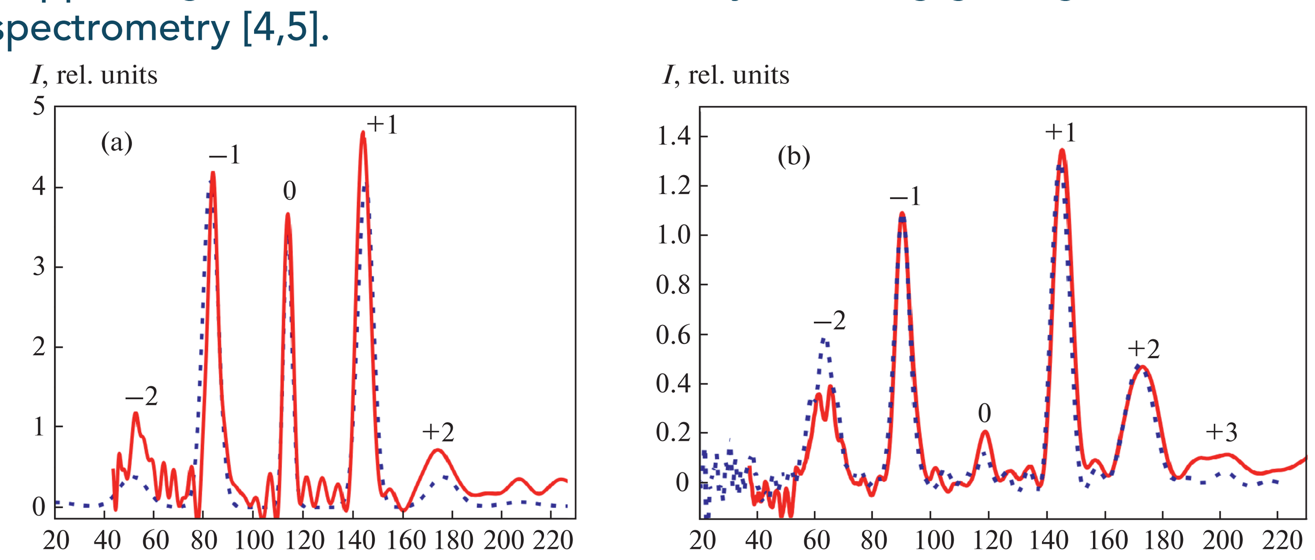
Effect of neutron energy change in diffraction by a moving grating was predicted in Ref. [1]. It was shown that when the amplitude or phase grating moves across the neutron beam the grating can act as a quantum modulator of the neutron wave transforming the spectrum of transmitted neutrons. As a result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

Firstly phenomenon was demonstrated in experiment [2] using phase diffraction grating.





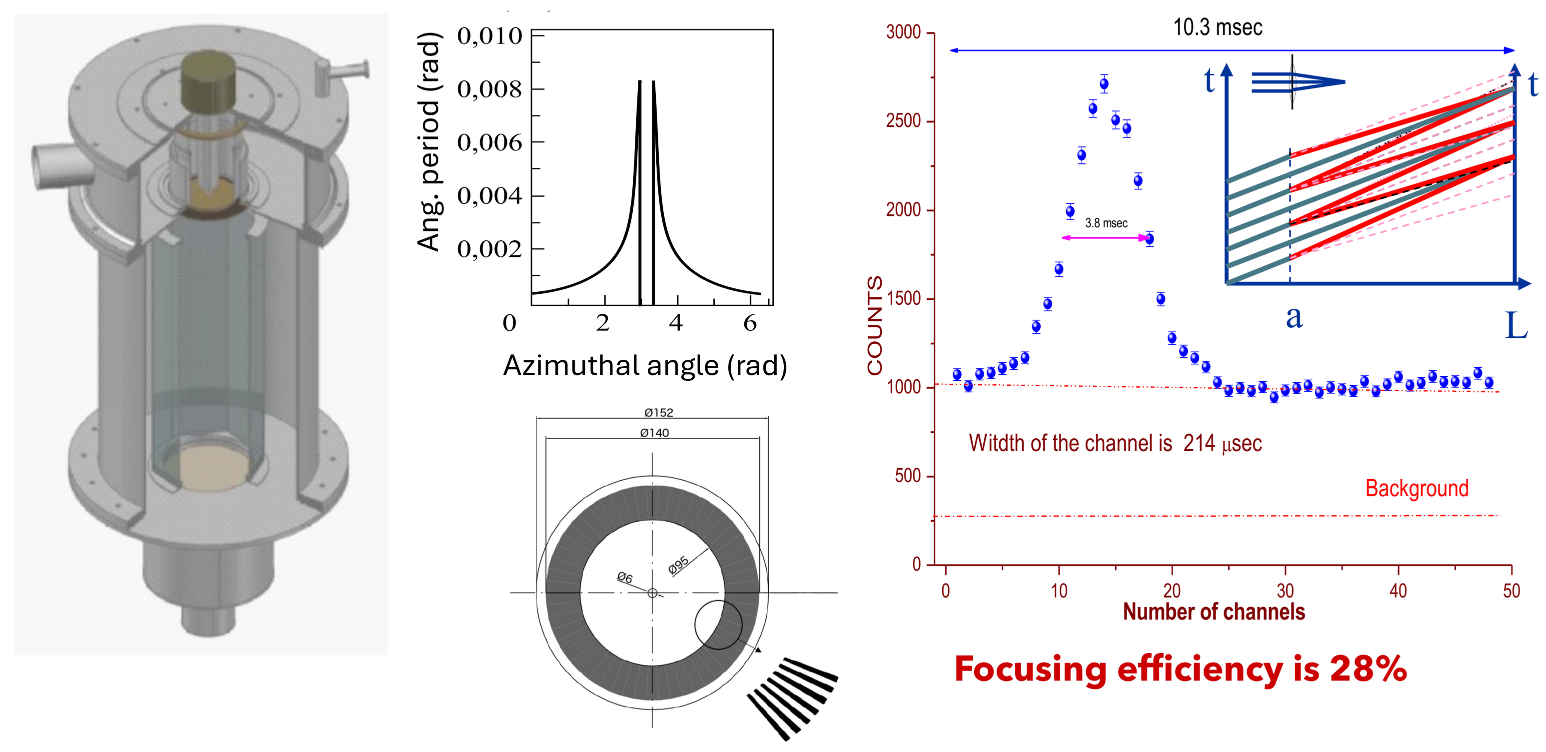
For a more rigorous description of the phenomenon, taking into account the three-dimensional structure of the moving grating, a variant of the multi-wave dynamic diffraction theory was developed [3]. To compare predictions of this theory, the spectra of ultracold neutrons appearing due to neutron diffraction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



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

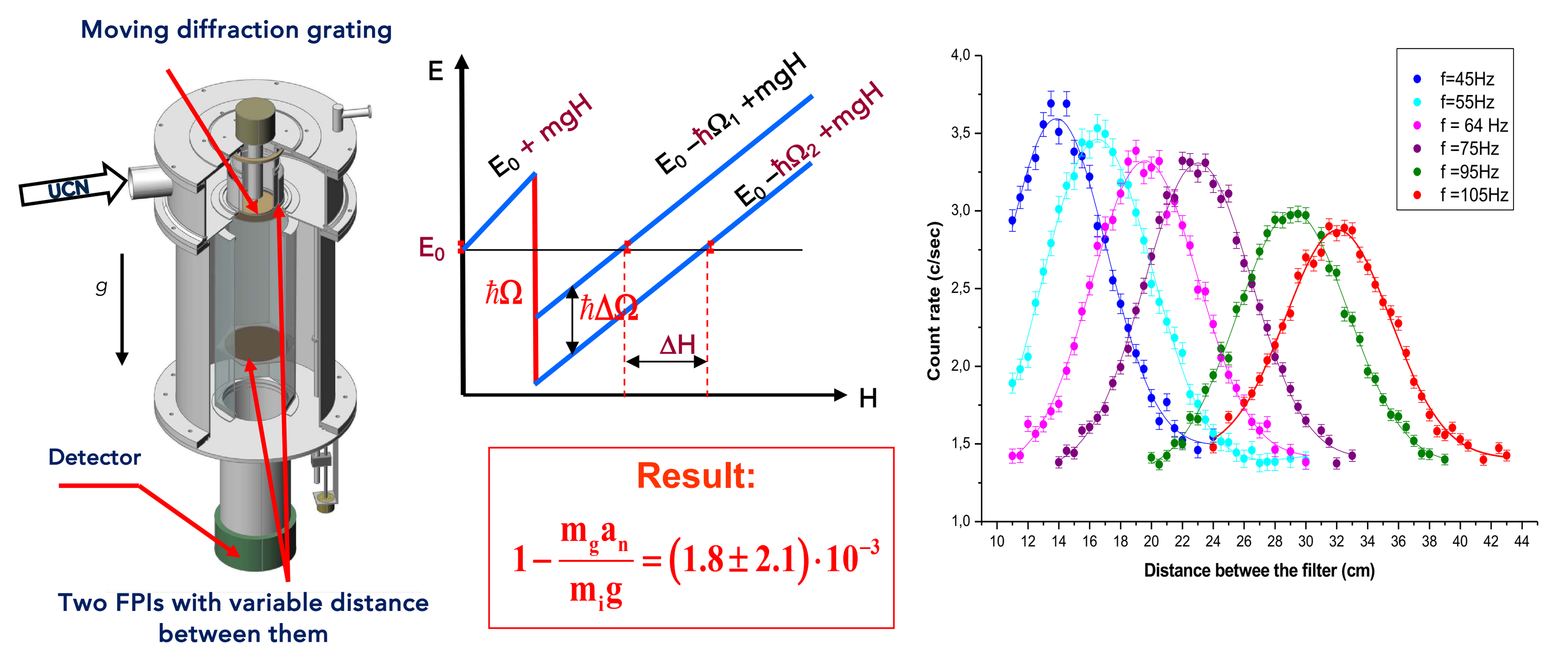
APPLICATION

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.



Focusing efficiency is 28%

The nonstationary phenomenon of neutron diffraction by a moving grating has found its application in the experiments testing the weak equivalence principle for the neutron [8] **The idea was to compare energy $m_g g_n H$ with energy transferred to neutron $\hbar\Omega$**

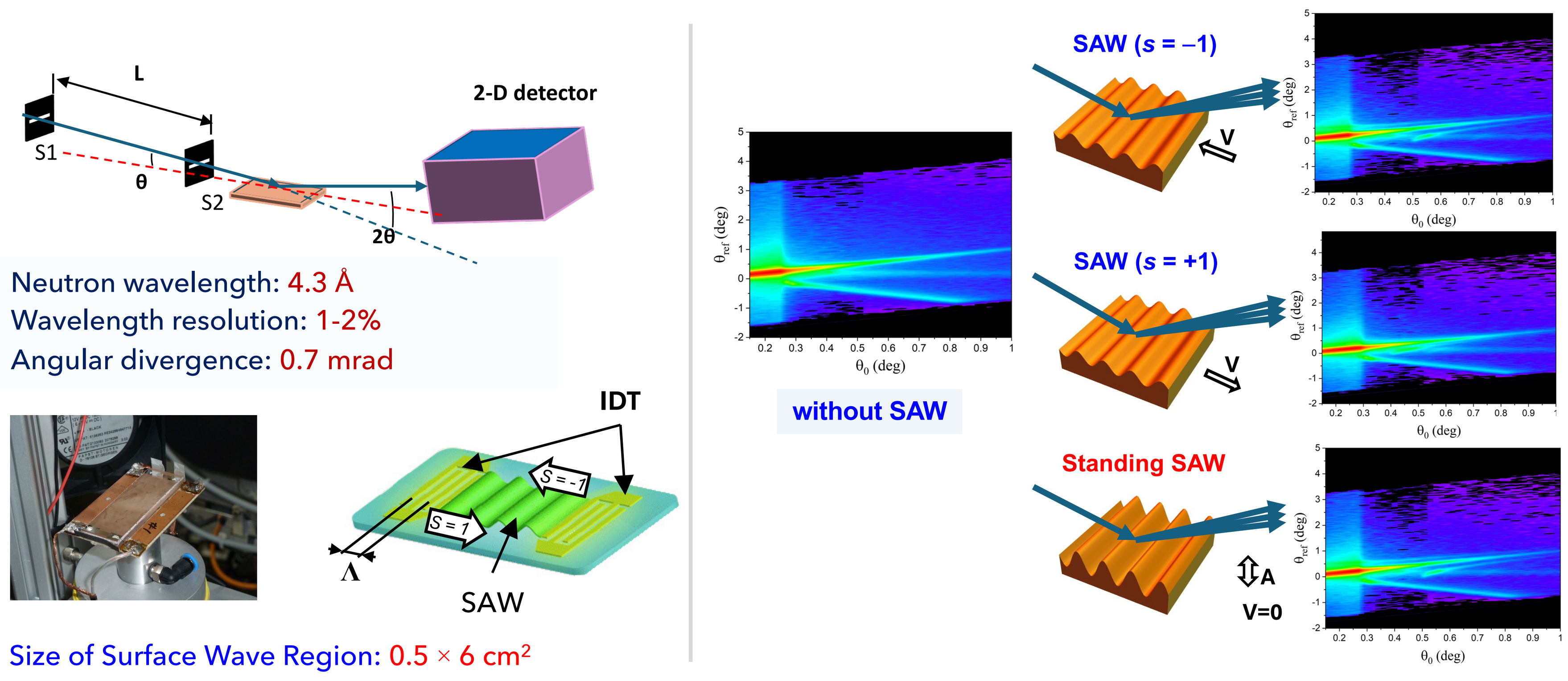


SURFACE ACOUSTIC WAVE (SAW)

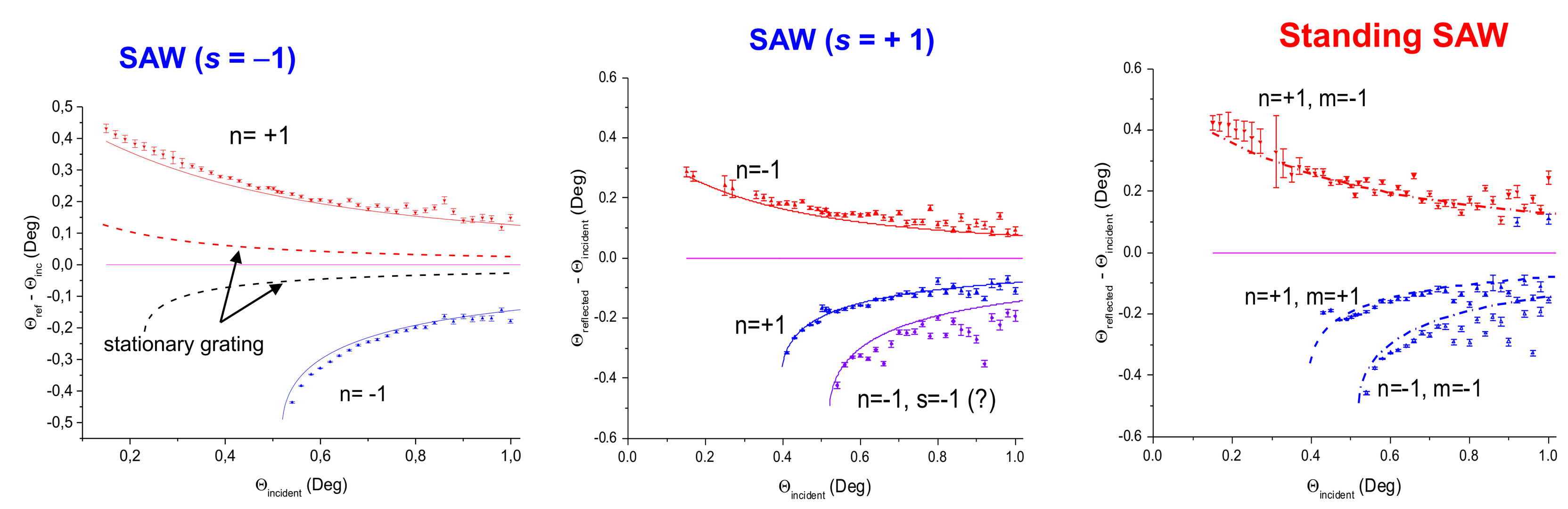
Neutron diffraction on a running wave is an essentially non-stationary process resulting in transfer of energy $E=n\hbar\Omega$ to the neutron. Here Ω is the wave frequency and n is an integer. The first, and until recently, only, experiment on the observation of neutron diffraction by a traveling SAW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

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 ultrasonic wave this acceleration reaches values of the order of 10^7g. The validity of the concept of the effective potential of matter in the case of such large accelerations, is not obvious a priori.

In the experiment [10] performed at the angle dispersive (λ=4.3Å) NREX reflectometer (MLZ, Munich) we used a YZ-cut of a $LiNbO_3$ crystal. On its surface two interdigital transducers (IDT) were disposed to excite travelling or standing waves with a frequency of 69 MHz.

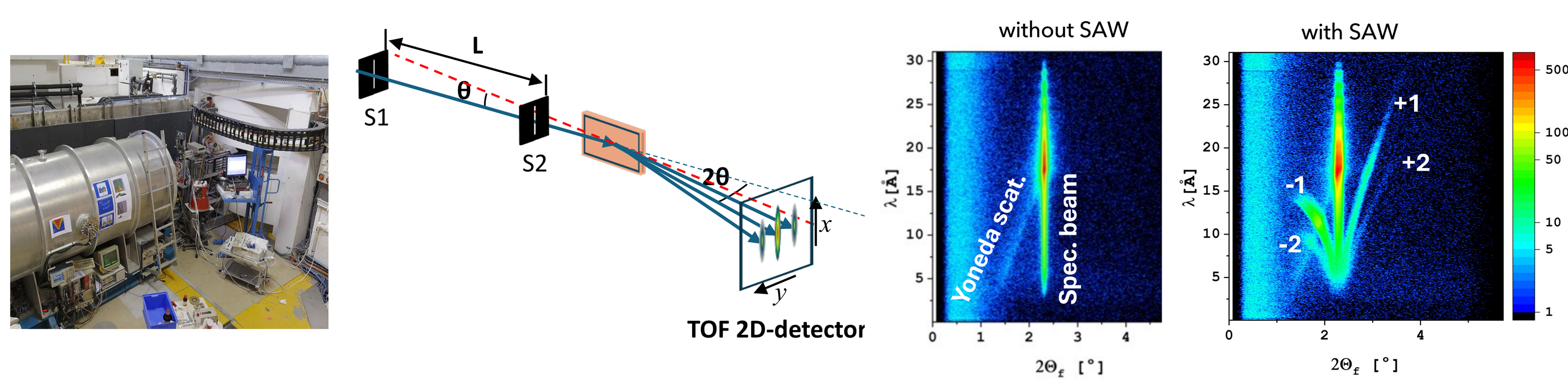


To excite travelling wave a high-frequency electrical signal was applied to one or to another IDT. To excite a standing SAW a voltage was applied synchronously to both IDTs

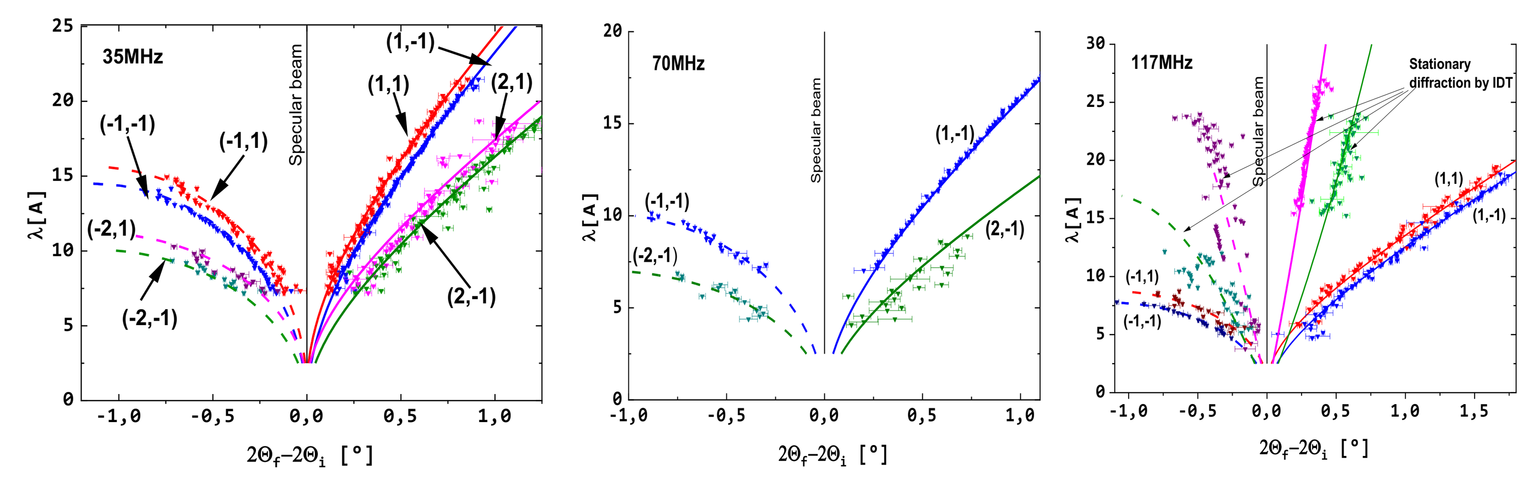


The experimental results are mostly consistent with theoretical predictions. The results obtained for diffraction by a standing wave are in complete agreement with the concept of it as a superposition of two traveling waves.

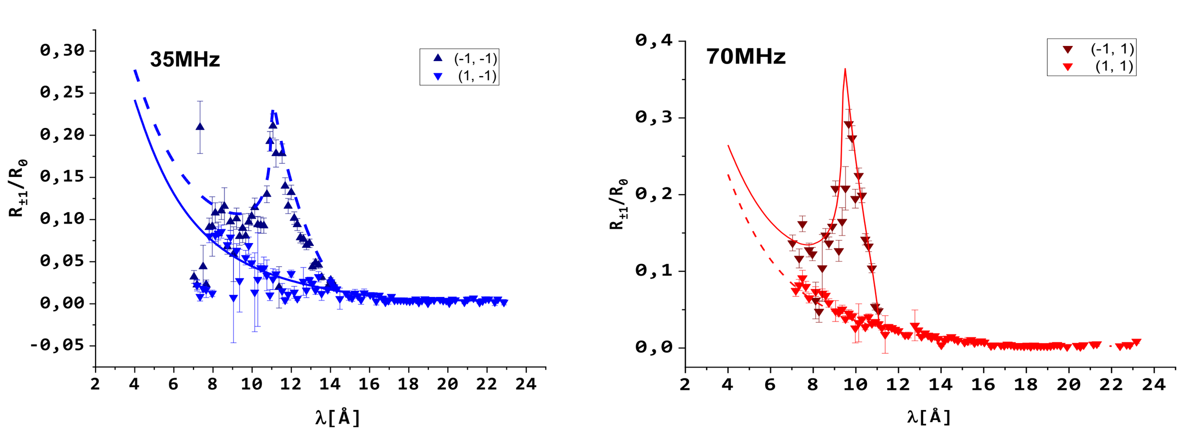
In the experiment at D17 Reflectometer (ILL, Grenoble) measurements were carried out at a fixed incident angle in the time-of-flight mode, which made it possible to study the diffraction pattern in a wide range of neutron wavelengths



Measurements were carried out for wavewlengths from 5 to 25Å. Samples were designed for 35, 70 and 117MHz



Angular distributions of diffracted beams, depending on the wavelength of the incident beam



Relative intensity ± 1 order of diffraction

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 5×10^8 m/s² !!!

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