THE METHOD OF SCATTERED ELECTRON SPECTRUM DIVISION INTO RESONANCE AND QUASIELASTIC PARTS IN THE ENERGY REGION OF GIANT RESONANCES

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The pioneer method for extraction of quasielastic part from the spectrum of scattered electrons is proposed. The essence of the method is in simultaneous multipole analysis of the mix of quasielastic and resonant formfactors. The identification of resonant peaks and quasielastic part of the formfactor have been held not in scattered electron spectra but in the transition probability energy dependence of each multipolarity where there difference between resonant and quasielastic processes is clear. The pure quasielastic spectrum for ^{65}Cu with the electron energy E_0=225 MeV and scattered angle θ=65° was obtained as a result of the application of this method.

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The results of the investigation of giant resonances (GR) by means of the inelastic electron scattering depend strongly from the quasielastic (QE) background, which should be extracting before analyzing the strength and multipolarity of giant resonances. Analyzing its formfactor angular dependence carries out the definition of the Giant resonance multipolarity. At the same time in experiment one can measure only the sum of GR and QE background. The last one has its own angular dependence, which is unknown up to now. To found the multipolarity of GR it is necessary to separate correctly the GR formfactor from the QE background at each angle and energy. Up to now this process was carried out mostly by means of the phenomenological formulas of the QE formfactor energy dependence with further normalization for given spectrum. At the same time the energy dependence of pure QE cross section is interesting in itself as an object for verification of different models of QE electron scattering. Up to now the energy and angular dependence of QE cross section at the energy region of giant resonances is unknown because of impossibility to separate QE part of the spectrum from the resonance part. All testing of different theoretical QE scattering models were carried out at high excitation energies where there are any resonances. Fig. 1 shows the example of different QE formfactor (F^2) excitation energy (E_x) dependences that were used earlier in giant resonance investigations.

We first propose the method to divide an electron scattering spectrum into resonance and QE parts. This method is based on the so-called “bin” technique, which has been successfully tested in the energy region where the QE process is absent [3].

We have applied this method to electroexcitation of ^{65}Cu and represent here the pure QE spectrum of scattered electrons obtained for the initial electron energy E_0=225 MeV and scattered angle θ=65°.

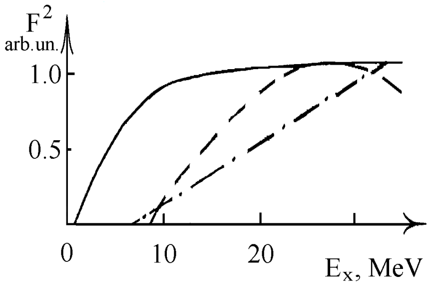

Fig. 1. *The example of different quasielastic formfactor energy dependences. Straight line – [1], dash line – [2], dash-dotted line – Fermi gas model*

The experiment was carried out at the LINAC-300 of NSC KIPT.

The isotopicaly enriched Cu (93,9% ^{65}Си) disc with the thickness of 0.266 g/cm^2 was used as a target. The disc has thickness homogeneity better then 1%, and chemical purity better then 99.9 %. The scattered electrons were analyzed by magnetic spectrometer and were detected by multichannel scintillation - Cherenkov detector. The energy range of one channel was 0.15%. The electron current was measured by secondary electron monitor, which was calibrated by Faraday cap. The system of the beam energy compression [4] was used for the energy resolution improvement and background suppression. The total resolution in these experiments was ~ 0,3%.

There were measured 11 spectra for initial electron energy E_0=150 and 225 MeV for scattered angles from 34° up to 74°. The radiation corrections were approached to each spectrum according to formulas of the work [5]. The elastic scattering peak was approximated by the Gauss function and extracted from the data.

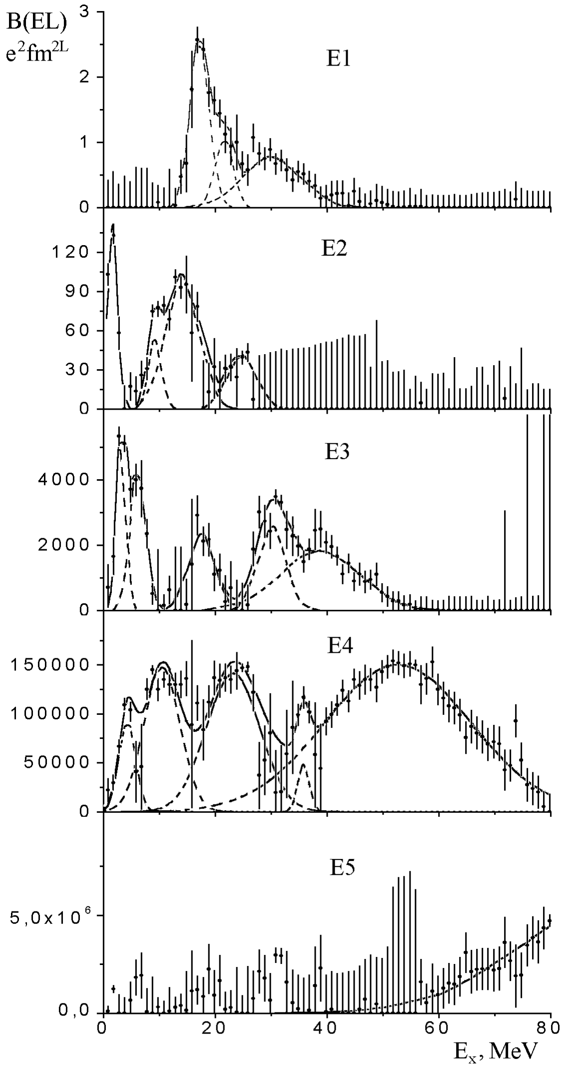

Fig. 2. *The reduced transition probability B(Eλ) for ^{65}Cu nuclei. Dash curves - result of Gaussian least square fitting. Solid line – sum of all Gaussians*

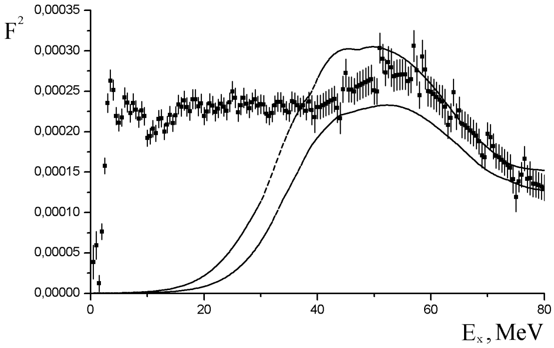

Fig. 3. *The formfactof of ^{65}Cu, E_0=225 MeV, θ=65°. The upper and lower curves – pure quasielastic formfactor taking into account the errors in Gaussian parameters*

The obtained spectra of inelastic scattered electrons were divided into bins of 0.5 MeV and averaged. These spectra were used for formfactor calculation:

$$F^2(q') = (d^2\sigma/d\Omega dE)_{\text{inelastic}}/\sigma_{\text{Mott}},$$

where: σ_{Mott} is the Mott cross section, $q' = q(1+3Ze^2/2E_0R_0)$, $R_0 = 1{,}3\cdot A^{1/3}$ fm, Z is nuclear charge, $q^2 = E_0^2+(E_0-\omega)^2-2E_0(E_0-\omega)\cos\theta$, ω is the energy transferred.

Then the multipole analysis was carried out for each energy bin. In this analysis the total formfactor was considered as a sum of five formfactors with different multipols.

$$F^2 = \sum_{L=1}^{5} \beta_L F_{EL}^2,$$

where E is means electrical transition,
L is multipolarity, β_L is least square fitting coefficients
F_{EL} is Helm formfactors.

$$F_{EL}^2 = J_L^2(q'R)\exp(-q'^2g^2),$$

where $J_L(q'R)$ is the Bessel function. R = 4.39 fm and g = 0,82 fm were obtained from approximation of the ^{65}Cu experimental elastic scattering formfactor with Helm formfactor.

The least square fitting coefficients β_L were recalculated to the reduced probability B(EL):

$$B(E_L) = \beta_L Z^2 R^{2L} e^2/4\pi.$$

The details of experimental technique being used, methods of measuring spectra of scattered electrons and processing the data obtained may be found in [6] and references in it. The only difference in data acquisition is that we didn't calculate and subtract any QE spectrum.

As a result the reduced probability B(Eλ) energy dependence was obtained for each multipolarity λ (Fig. 2). It is clear that at high excitation energy (>50 MeV) there is any resonances and we see energy dependence of QE reduced probability. So we consider reduced probability energy dependence for each multipolarity as a sum of giant resonances and much more broad high-energy maximum corresponding to QE process. The Gaussian function was fitted to each experimental maximum by least square method.

The Gaussian shape obtained for each multipolarity (excepting E2) of the high energy maximum gives us energy dependence of the QE process. The momentum transfer energy dependence for each multipolarity is given by Helm formfactor. So the QE cross section now may be represented as sum of Helm formfactors with Gausian amplitudes.

While the Helm formfactors are determined precisely each Gausian has three parameters with its own uncertainty. To understand the accuracy of the reconstruction process 2^3 combinations were calculated with all possible combinations of upper and lower limits of the Gausian parameters. Then the maximum and minimum values were determined among these combinations for each multipolarity and summarized after multiplication by corresponding Helm formfactor. Fig. 3 shows the result of such reconstruction process.

Comparing the obtained result with previously used quasielastic curves it is clear that at the energy region of 10…30 MeV the resonant formfactor was underestimated in all previous works of GR investigation. And the much more bigger problem is that this effect may lead to another angular dependence of experimental multipole GR formfactor. In tern this causes wrong determination of the GR multipolarity. Such effect is important for big angles where the contribution of quasielastic process in total formfactor is essential. It means that one can expect the significant changing in structure of GRs with high multipolarity. The previously obtained results for dipole and may be quadrupole GR probably will not change.

The proposed new approach in elastic electron scattering spectra treatment opens possibility not only to investigate the qusielastic process at low transfered energy but also to determine correctly the structure of GR with high multipolarity.

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МЕТОД РАЗДЕЛЕНИЯ СПЕКТРОВ РАССЕЯННЫХ ЭЛЕКТРОНОВ НА РЕЗОНАНСНУЮ И КВАЗИУПРУГУЮ ЧАСТИ В ОБЛАСТИ ЭНЕРГИЙ ВОЗБУЖДЕНИЯ ГИГАНТСКИХ РЕЗОНАНСОВ

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Предложен новый метод для извлечения квазиупругой (КУ) части из спектра рассеянных электронов. Сущность метода заключается в одновременном мультипольном анализе смеси КУ и резонансного сечения. Идентификация резонансных пиков и КУ части сечения проводится не в спектрах рассеянных электронов, а в энергетической зависимости приведенной вероятности каждой мультипольности, где имеющееся различие между резонансным и КУ процессами проявляется более ясно. Чистый КУ спектр для ядра ^{65}Cu при начальной энергии электронов $E_0 = 225$ МэВ и угле рассеяния $\theta = 65°$ получен как результат применения этого метода.

МЕТОД ПОДІЛУ СПЕКТРІВ РОЗСІЯНИХ ЕЛЕКТРОНІВ НА РЕЗОНАНСНУ І КВАЗІУПРУЖНУ ЧАСТИНИ В ОБЛАСТІ ЕНЕРГІЙ ЗБУДЖЕННЯ ГІГАНТСЬКИХ РЕЗОНАНСІВ

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Запропоновано новий метод для витягу квазіпружної (КП) частини зі спектра розсіяних електронів. Сутність методу полягає в одночасному мультипольному аналізі суміші КП і резонансного переріза. Ідентифікація резонансних піків і КП частини переріза проводиться не в спектрах розсіяних електронів, а в енергетичній залежності приведеної імовірності кожної мультипольності, де наявне розходження між резонансним і КП процесами виявляється більш ясно. Чистий КП спектр для ядра ^{65}Cu при початковій енергії електронів $E_0 = 225$ МеВ і куті розсіювання $\theta = 65°$ отримано як результат застосування цього методу.