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NEUTRON WAVELENGTH EFFECTS ON NEUTRON FLUX CROSS – SECTION

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Abstract

In this study, a numerical method for correcting neutron scattering cross-sections for fundamental elements in the low-energy neutron range frequently employed in neutron scattering experiments is presented, and a mathematical connection between these variables is established by applying the through experimentation observed power law describing the cross-section-neutron wavelength relationship. The central moment expansion approach is used to get the corrections, which allow cross-sections to be adjusted for typical neutron wavelength distributions found in experiments. Notably, previous knowledge of the functional form of the distribution is not necessary for the suggested technique to work. This makes it possible to reconstruct neutron scattering data more precisely by removing distortions brought about by energy-dependent cross-sections of different elemental materials during measurements. In the end, this invention improves the accuracy of deciphering and evaluating material structures by utilizing their scattering characteristics.

Key words

SANS,Neutron flux, cross – section, electric charge.

ВЛИЯНИЕ ДЛИНЫ ВОЛНЫ НЕЙТРОНА НА СЕЧЕНИЕ НЕЙТРОННОГО ПОТОКА.

Аннотация

В этом исследовании представлен численный метод коррекции сечений рассеяния нейтронов для фундаментальных элементов в диапазоне нейтронов низкой энергии, часто используемых в экспериментах по рассеянию нейтронов, и установлена математическая связь между этими переменными путем применения экспериментально наблюдаемого степенного закона, описывающего зависимость сечения от длины волны нейтрона. Для получения поправок используется подход расширения центрального момента, который позволяет корректировать сечения для типичных распределений длин волн нейтронов, обнаруженных в экспериментах. Примечательно, что для работы предлагаемого метода не требуется предварительного знания функциональной формы распределения. Это позволяет более точно реконструировать данные рассеяния нейтронов, удаляя искажения, вызванные зависящими от энергии сечениями различных элементарных материалов во время измерений. В конечном итоге это изобретение повышает точность расшифровки и оценки структур материалов за счет использования их характеристик рассеяния.

Ключевые слова

SANS, нейтронный поток, сечение, электрический заряд.

NEYTRON TO'LQIN UZUNLIGINING NEYTRON OQIMI KESIMIGA TA'SIRI.

Annotatsiya

Ushbu ishda neytronlarni sochish tajribalarida tez-tez qo'llaniladigan past energiyali neytron diapazonidagi fundamental elementlarning neytronlarning sochilish kesimlarini to'g'rilashning raqamli usuli taqdim etilgan va bu o'zgaruvchilar o'rtasidagi matematik bog'liqlik kuzatilgan tajribani qo'llash orqali o'rnatiladi. Neytron to'lqin uzunligining ko'ndalang kesimi munosabatini tavsiflovchi kuch qonunidir. Tajribalarda topilgan neytron to'lqin uzunligining odatiy taqsimotlari uchun kesmalarni sozlash imkonini beruvchi tuzatishlarni olish uchun markaziy momentni kengaytirish yondashuvi qo'llaniladi. Ta'kidlash joizki, tavsiya etilgan texnikaning ishlashi uchun tarqatishning funktsional shakli haqida oldingi bilimlar shart emas. Bu o'lchovlar paytida turli xil elementar materiallarning energiyaga bog'liq bo'lgan kesmalari natijasida yuzaga kelgan buzilishlarni olib tashlash orqali neytronlarning tarqalishi ma'lumotlarini aniqroq qayta qurish imkonini beradi. Oxir-oqibat, ushbu ixtiro material tuzilmalarini ularning tarqalish xususiyatlaridan foydalangan holda shifrlash va baholashning aniqligini yaxshilaydi.

Kalit so'zlar

SANS, Neytron oqimi, ko’ndalang kesim, elektr zaryadi.

1. Introduction

The contrast variation method, which is frequently used in conjunction with SANS, allows researchers to emphasize specific components within complex materials by adjusting the neutron scattering contrast among various isotopes or material phases. But the success of this approach depends on precise knowledge of the scattering cross-sections of each element and isotope present in the system; these cross-sections are wavelength-dependent, and their variability with neutron energy must be carefully accounted for in order to normalize the scattered intensities across the full reciprocal Q-space range probed during experiments. Neutron flux guarantees that high-quality, dependable data is obtained from small-angle neutron scattering (SANS) experiments in order to analyze the structural properties of soft materials and biological systems at the mesoscopic scale.

In conclusion, precise, high-resolution structural insights in SANS studies depend on optimizing neutron flux and carefully taking scattering cross-section fluctuations into account. When paired with contrast variation methods, SANS remains a potent tool for examining the intricate structural heterogeneity of soft matter and biological systems at mesoscopic scales.

In order to address and rectify the energy dependency and fluctuations seen in neutron scattering cross-sections, this study attempts to provide a solid mathematical foundation. In typical small-angle neutron scattering (SANS) experiments, the framework is particularly made to match the energy spectrum of incoming neutrons.

2. Results

Neutrons may easily enter atomic nuclei and cause nuclear reactions since they don't have an electric charge. Since the atomic nucleus is the primary object of neutron interactions, it is appropriate to ignore the function of electrons and treat atoms and their nuclei as interchangeable in this context. The energy dependency of the interaction cross-sections must be carefully considered since neutron reactions may take place across a wide energy range.

Neutron energies of interest in nuclear reactors vary from 10^{-5} eV to 10^{7} eV . As a function of the incident neutron energy E, Figure 1 shows the total scattering cross-sections, $\sigma(E)$ σ(E), for a number of elements that are frequently present in soft materials, such as hydrogen (H^1), deuterium (D^2), carbon (C^6), nitrogen (N^7), oxygen (O^8), and sulfur (S^{16}). Here, the number of protons in each nucleus is indicated by the superscripts in the atomic notation. An analysis of the general behavior of $\sigma(E)$, as shown in Fig. 1, offers important information on neutron scattering cross-sections. First, if the neutron energy is greater than $E > 0.1$ MeV, there are noticeable and erratic fluctuations in $\sigma(E)$. The internal structure of compound nuclei, which affects the scattering behavior at higher energies, is the main source of these variations.

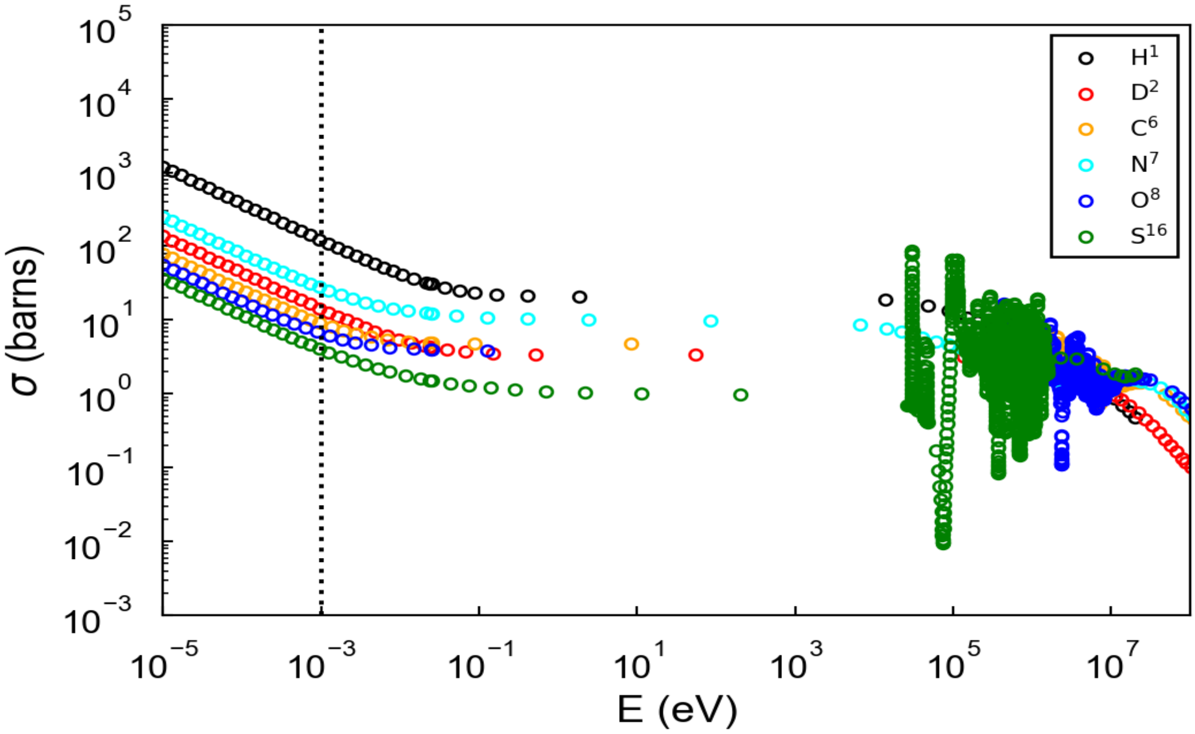

Figure 1: Overall scattering cross sections of various components as a function of energy

σ(E) stabilizes as the energy drops, holding steady at a comparatively consistent value throughout a wide range of energies from 10^4 to 10^5 eV. The free-atom cross-section is a common term used to describe this energy-independent area of scattering behavior. The Fermi pseudopotential model and the Born first approximation provide a theoretical explanation for the observed s-wave scattering behavior in this region.

$$ln[\sigma(E)/\sigma_0] = K + mln[E/E_0] \qquad (1)$$

Here, K is an energy-independent, dimensionless constant, and $\sigma(E)$ is the neutron scattering cross-section as a function of energy E. The slope that results from graphing $ln[\sigma(E)/\sigma_0]$ versus $ln[E/E_0]$ for low neutron energies is represented by the parameter m. Here, the logarithmic inputs are kept dimensionless by using σ_0 and E_0 as normalization factors for the cross-section and energy, respectively. Regression analysis may be used with experimental data to extract the values of these variables for various elements after σ_0 and E_0 have been specified. The log-log plot of $\sigma(E)$ vs E for hydrogen, deuterium, carbon, nitrogen, oxygen, and sulfur is shown in Figure 2. There is a recurring pattern among all of these components:

$$\sigma(E) = A\sigma_0\left(\frac{E}{E_0})^m\right)) \qquad (2)$$

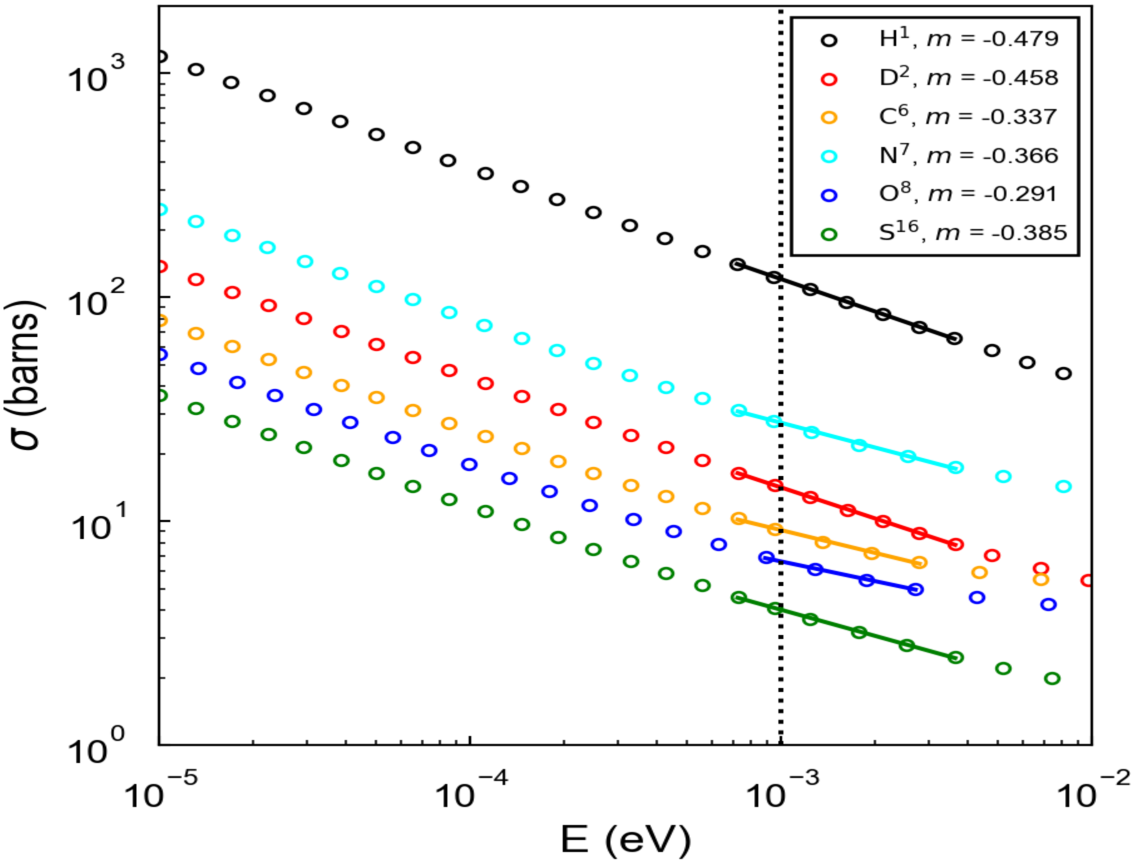

Figure 2: The lower-energy area seen in Figure 1. The slope in this log-log form appears to fluctuate between around -0.3 and -0.5.

3. Conclusion

Effective execution, precise interpretation, and in-depth analysis of Small-Angle Neutron Scattering (SANS) studies need a thorough grasp of neutron energy dependence. This information guarantees that experimental findings are not only trustworthy but also offer insightful information on the intricate structures and special qualities of the materials under study.

Our goal in this research has been to improve the accuracy of scattering cross-sections derived from experimental SANS data by creating a methodical and reliable approach. This method advances SANS research by directly tackling the problems caused by neutron energy dependency, allowing researchers to glean more accurate and comprehensive data from their studies. In scientific fields where SANS is essential, this improved precision promotes innovation and advances by enabling a greater knowledge of the materials under study.

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