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A Wide Scaled Analysis of Elastic Scattering of ^{2}H, ^{4,6}He, ^{6,7,8}Li, ^{7,9}Be, ^{8,11}B and ^{18}O from ^{58}Ni at Various Energy Region

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Abstract: Wide scaled analysis of angular distributions for the elastic scattering of ^{2}H, ^{4,6}He, ^{6,7,8}Li, ^{7,9}Be, ^{8,11}B and^{18}O from ^{58}Ni have been calculated theoretically at various MeV energy region over an angular range from 0° to 180° in 20° steps by way of NRV Knowledge Base. The elastic scattering of these nuclei from ^{58}Ni have been studied within the frame of the classical, semi-classical and optical-model parameters. Elastic angular distributions have been calculated graphically and these results have been compared with results of experimental investigations. These benchmarkings provide information about the similarities and differences of the models used in the calculations.

Keywords: Elastic Scattering, NRV Project, Optical Model, Differential Cross Section, Angular Distributions.

Farklı Enerji Bölgelerinde ^{58}Ni'den ^{2}H, ^{4,6}He, ^{6,7,8}Li, ^{7,9}Be, ^{8,11}B ve ^{18}O'in Elastik Saçılmasının Geniş Ölçekli Analizi

Özet: ^{58}Ni'den ^{2}H, ^{4,6}He, ^{6,7,8}Li, ^{7,9}Be, ^{8,11}B ve ^{18}O'in elastik saçılımı için açısal dağılımların geniş ölçekli analizi teorik olarak farklı MeV enerji bölgelerinde NRV Bilgi Tabanı vasıtasıyla 20°'lik adımlarla 0° ile 180° açısal aralığında hesaplanmıştır. Bu çekirdeklerin ^{58}Ni'den elastik saçılımı, klasik, yarı-klasik ve optik model parametreleri çerçevesinde incelenmiştir. Elastik açısal dağılımlar grafiksel olarak hesaplanmış ve bu sonuçlar deneysel araştırmaların sonuçları ile karşılaştırılmıştır. Bu kıyaslamalar, hesaplamalarda kullanılan modellerin benzerlikleri ve farklılıkları hakkında bilgi sağlar.

Anahtar Kelimeler: Elastik Saçılma, NRV Projesi, Optik Model, Diferansiyel Tesir Kesiti, Açısal Dağılımlar.

INTRODUCTION

Nuclear reactions can be seen in versatile configurations: elastic, inelastic, etc. We are prospected by using distinctive modalities. The elastic scattering of bullets from nuclei has been a very important discussion and the topic of hypothetical and empirical studies for many years. The essential intention of surveys is to comprehend the average area encountered by the bullet as it passes through the core. This area is generally explained in terms of the potential of an Optical Model (OM). The optical model is the uttermost used types in the literature for ventilation of elastic scattering. The optical model is a potential consisting of real and imaginary potential parameters. The real potential of optical model diagnoses the elastic scattering of the reaction. The imaginary potential represents the wantage of flux into inelastic channels. Real and imaginary potential parameters may be designated via phenomenological or microscopic models [1-2].

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Elastic scattering is simplest process and one of the most important reactions resulting from nucleus-nucleus interactions. At nominal energy regions, this is a superficies treatment and is therefore more convenient for analyzing surface properties such as set configuration and deformations. It is a very prestigious that the wide-angle elastic and inelastic scattering between the light and heavy-ion couples is attributed to the single particles or the collective configurations of the interacting nuclei.

THEORETICAL MODEL

In our work, we used the Nuclear Reaction Video (NRV) Project. It is a online information base effectuated by the Joint Institute for Nuclear Research (JINR) to calculate nominal energy nuclear physics. This online knowhow base defragments a very extensive scale of nuclear features, modellings, empirical datas, computing programmes in the browser via a faraway occupier. In these days, this online knowhow base is a vigorous and influential apparatus for nuclear science investigation and an instructional origin. This program can make online video, graphics and calculations together. It consists of well-known theoretical models of various nuclear reactions in a continuously updated database. [3-7].

This online knowhow base disentangles the following essential affairs:

i. Rapid and visual acquisition and working of empirical input-output related to nuclear construction and reactions.

ii. The likelihood that an unpractised operator will investigate empirical data in trustworthy and widely secondhand nuclear structure samples.

The framework encapsulates an optical and classic model of the elastic scattering of the core. These authorise the wielder to work out the differential cross section of elastic scattering, fractional wave functions, S-matrix, phase shifts, field of orbits, the deviation function. The selection of the optical model parameters in accordance with the universal parametrizations and the contingency of regulation them automatically to the empirical informations by manual input by the user streamlines the decomposition in a simple way.

The relativistic movement of the bullet and target is explained with a Scrödinger equation in an optical model of elastic scattering (OM) [8].

$$\left[-\frac{\hbar^2}{2m}\Delta + V_{OM}\right].\Psi_{\vec{k}}^{(+)}(r,\theta) = E\Psi_{\vec{k}}^{(+)}(r,\theta)$$

The relativistic movement energy is

$$E = \hbar^2 k^2/2\mu$$

in here μ is the deductible mass. V_{OM} is the influential non-hermitian operator called optical potential. In point of fact, optical potential with a elementary radial dependency is frequently used

$$V_{OM}(r) = V_C(r) + V_N(r) + iW(r) + [V_{SO}(r) + iW_{SO}(r)].(\vec{l}.\vec{s})$$

Coulomb and nuclear mutual effects are $V_C + V_N$ as above, the virtually part of optical model potential is selected in the volume or surface Woods-Saxon forms. $V_{SO} + iW_{SO}$ is the spin-orbital interaction that may be encapsulated while the bullet has a non-zero spin.

The relativistic movement wave function with an infinite limit circumstance is

$$\Psi_{\vec{k}}^{(+)}(r,\theta) \approx e^{ikrcos\theta} + f(\theta)\frac{e^{ikr}}{r}$$

$f(\theta)$ is the scattering amplitude. The total wave function should be split into the partial waves to come up with the scattering magnitude

$$\Psi_{\vec{k}}^{(+)}(r,\theta) = \sum_{l=0}^{\infty}(2l+1)i^l\psi_l(r)\,P_l(cos\theta)$$

afterwards Schrödinger equations must be integrated numerically from $r = 0$ up to some large distance $r = R_{max}$. $V_N(r)$ and $W(r)$ may be disregarded but just the Coulomb mutual effect continues. In this wide range the computational analysis is properly combined by a known asymptotic attitude of the partial wave

$$\psi_l(r) \approx e^{i\sigma_l}\frac{1}{2}[(F_l + iG_l) + S_l(F_l - iG_l)]$$

F_l and G_l are the regular and irregular Coulomb partial wave functions. After finding the partial S-matrix components, the nuclear scattering amplitude can then be calculated

$$f_C(\theta) = -\frac{\eta}{2k}\frac{1}{sin^2\theta/2}exp[2i(\sigma_0 - \eta lnsin\theta/2)]$$

$$f_N(\theta) = \sum_{l=0}^{\infty}(2l+1)i^{2i\sigma_l}\frac{S_l - 1}{2ik}P_l(cos\theta)$$

in here $S_l = exp(\delta_l)$ are the fractional matrix elements and δ_l are the fractional nuclear phase shifts. $\sigma_l = arg\Gamma(l + 1 + i\eta)$ are the Coulomb phase shifts, $\eta = k(Z_1Z_2e^2)/2E$ is the Sommerfeld parameter. These parameters may be computed numerically according to solving the radial Schrödinger equations. [3-7].

The differential cross section

$$\left[\frac{d\sigma}{d\Omega}(\theta)\right]_{elastic} = |f_C(\theta) + f_N(\theta)|^2$$

In order to a dedicated series of the optical model parameters, NRV's optical model script computes and presents all of the upstairs quantities in diagrammatic and chart forms. An self-inflicted exploration of the parameters may be carried out via an adaptation of the elastic scattering angular dispersion calculated to the present empirical data. A number of supplementary probabilities have been added to the NRV's optical model code, which consents for a detailed analysis of the continuum being examined. [3-7].

Optical potential parameters listed in Table 1 is used in the NRV calculations.

Table 1. The parameters of optical model of elastic scattering for NRV calculations.

System	E_{cm} (MeV)	E_{lab} (MeV)	V_0 (MeV)	r_0 (R) (fm)	W_0 (MeV)	a (fm)	k (fm^{-1})	R_{max} (fm)	dr (fm)
$d+^{58}Ni$	116	120	40±3	1.12	16±2	0.650	3.275	17.130	0.09
$^4He+^{58}Ni$	161.371	172.5	55±2	1.12	25±3	0.600	5.374	14.460	0.05
$^6He+^{58}Ni$	8.156	9	45±2	1.12	25±1	0.700	1.456	14.881	0.20
$^6Li+^{58}Ni$	190.313	210	33±2	1.12	13±2	0.600	7.036	14.690	0.04
$^7Li+^{58}Ni$	16.311	18.28	61±1	1.12	49±1	0.800	2.208	14.780	0.13
$^8Li+^{58}Ni$	17.752	20.2	68±1	1.12	54±1	0.800	2.443	14.870	0.12
$^7Be+^{58}Ni$	19.095	21.4	75±1	1.12	55±1	0.750	2.389	14.780	0.12
$^9Be+^{58}Ni$	22.8	26.338	55±3	1.12	25±2	0.700	2.915	14.950	0.10
$^8B+^{58}Ni$	25.748	29.3	47±1	1.12	26±3	0.700	2.943	14.870	0.10
$^{11}B+^{58}Ni$	15.97	18.999	58±3	1.12	27±1	0.750	2.658	17.615	0.11
$^{18}O+^{58}Ni$	26.787	17.033	48±2	1.12	23±2	0.745	4.195	17.033	0.07

CALCULATIONS AND RESULTS

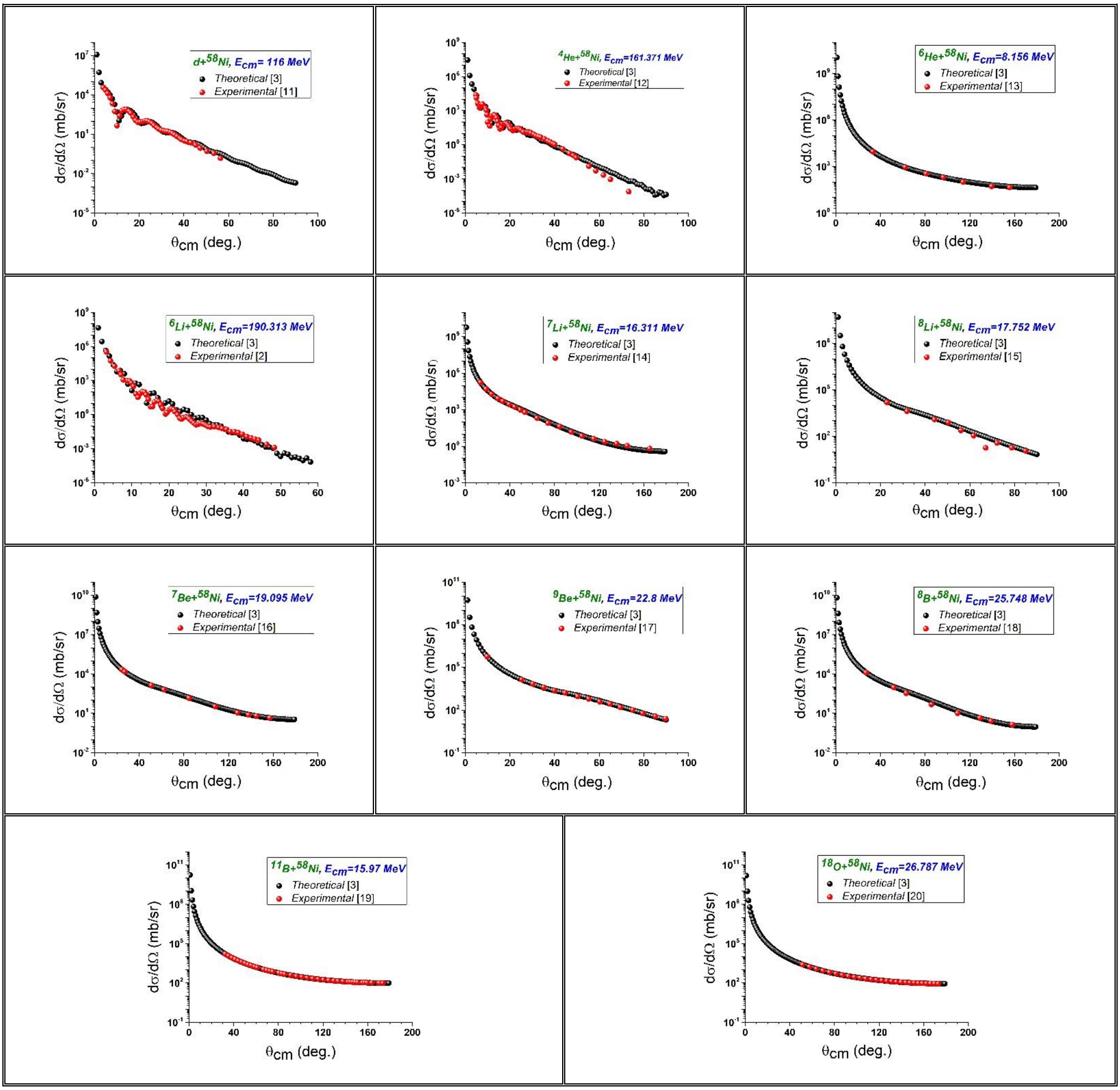

Figure 1. Comparison theoretical and experimental differental cross-section results of optical model calculations of ^{2}H, $^{4,6}He$, $^{6,7,8}Li$, $^{7,9}Be$, $^{8,11}B$ and ^{18}O from ^{58}Ni at various energy region [2-22].

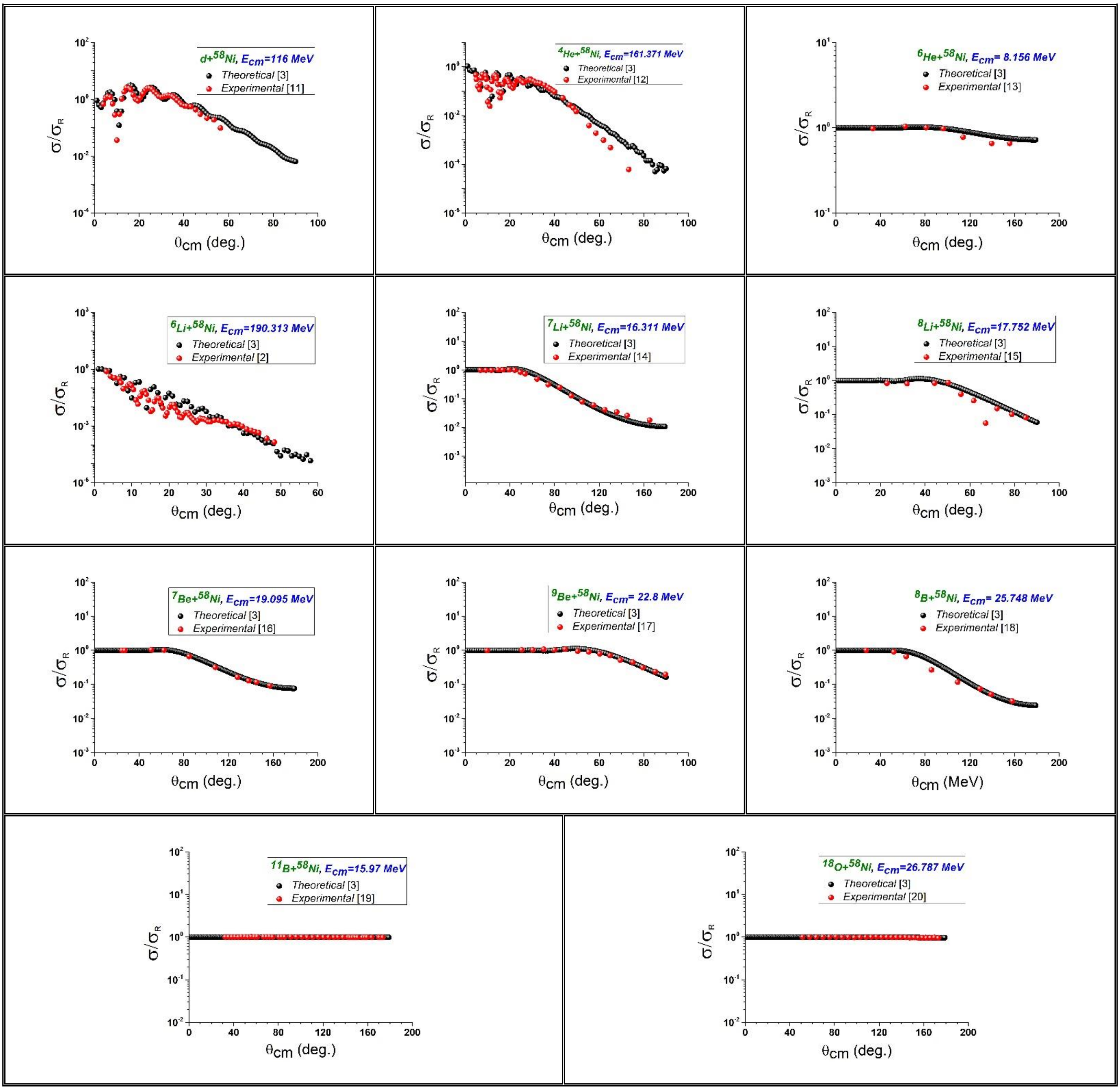

Figure 2. Comparison theoretical and experimental cross-section results of optical model calculations of ^{2}H, ^{4,6}He, ^{6,7,8}Li, ^{7,9}Be, ^{8,11}B and ^{18}O from ^{58}Ni at various energy region [2-22].

SUMMARY AND CONCLUSIONS

The reaction cross sections σ_R have been reckoned out of the multifarious series of optical potentials. Finally, because of the unique optic model potentials have been acquired for the ^{2}H, ^{4,6}He, ^{6,7,8}Li, ^{7,9}Be, ^{8,11}B, ^{18}O+^{58}Ni mutual effect at multifarious MeV energy region and their energy indulgence has been established. It is presently contingent to commentate the miscellaneous guidelines for the potential models. This will be the mainly topic of many research over the coming years.

In our work, it is shown as a vicinity way of scattering to comprehend the primary noteworthiness of the target-bullet impressions on the nuclear reaction process in the energy near the Coulomb barrier.

Elastic scattering is the most substantial characteristic of nuclear reactions. We can directly attain the variables of the mutual effect of the bumping particles, i.e., the most important nuclear characteristics, via one point of view from the decomposition of elastic scattering data. Moreover, the parameters of whatsoever nuclear reactions is designated to a prominent grade together with "elastic" movement of the bumping particles in the entry channel and of the shaped portions in the out channel. It expresses that decomposition of whatsoever nuclear reactions must initiate from a scrupulous study of elastic scattering of the nuclear particles entangled in the continuum.

The objective of the optical model is to describe the fast, direct contribution to nuclear scattering. It makes use of an optical potential having both real and negative imaginary parts. The absorption of flux from the optical wave function, due to the imaginary part of the potential, accounts for the flux lost to the slower, compound nucleus component of the scattering.

We have calculated angular dispersions for elastic scattering of different nucleus on ^{58}Ni at distinctive shelling energies in the neighborhood of the Coulomb barrier. Elastic scattering calculations of differential cross sections and cross sections of various MeV energy regions H, He, Li, Be, B and O ions have been made for ^{58}Ni. We have shown the results in Figs 1 and 2. Calculations in a limited angular range result in ambiguous potential clusters, while angular intervals are large enough to determine the optical modeling potentials. Unmistakably, calculations angles perfect into the region are requisited so as to discerner the accurate potentials from the multifarious models.

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