Colisión

$$\alpha - {}^{12}C$$

Modelo Óptico y Potencial Complejo

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Justificación

Las partículas alfa son relativamente fácil de producir, además de que son difíciles de separar. En particular, las partículas alfa son sondas adecuadas de la superficie nuclear debido a su carácter fuertemente absorbente.

El carbono 12 es abundante, estable, y es un núcleo par-par, lo que permite ignorar la interacción espín órbita y facilita la comprensión del problema.

La dispersión elástica nuclear nos permite comprender mejor la física nuclear y lo más importante aún, nos da un acercamiento a las reacciones nucleares donde las verdaderas aplicaciones aparecen y son diversas.

Al implementar un potencial complejo esto permite comprender el modelo óptico y así acceder a otro tipo de colisiones más complejas.

Antecedentes

- Como es hablamos de colisiones, se debe de tener en cuenta conceptos de la teoría de scattering como la sección eficaz y amplitud de dispersión [1].
- El índice de refracción de extinción (índice de refracción complejo) hace que se atenúe la onda electromagnético en dicho medio, este comportamiento de atenuación se comporta similar a los datos de dispersión elástica, es por esta razón, se propone un potencial complejo.

[1] Canto,L. & Hussein,S “scattering theory of molecules, atoms and nuclei”. world scientific, 2013.
[2]S. M. Smith et al. “THE (alpha, alpha), (alpha, alpha’) AND (alpha, 3He) REACTIONS ON 12C AT 139 MeV”. En: Nuclear Physics A207 (1973).

Estado del Arte

Elastic scattering analysis of α and ^{3}He particles on ^{12}C and ^{16}O using a complex folded potential

S. A. E. Khallaf, A. M. A. Amry, and S. R. Mokhtar
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(Received 2 January 1997)

The angular distribution of differential cross sections for α and ^{3}He projectiles elastically scattered from ^{12}C and ^{16}O are calculated at the energy range from 25 to 217 MeV. The double folding model with an energy-target density dependent Jeukenne, Lejeune, and Mahaux effective nucleon-nucleon interaction is used to obtain both real and imaginary parts of the central optical potential. The dependence of the potential on densities of projectile and target nuclei in a factorized form is considered. Good fits to the experimental data are obtained. Nuclear rainbow scattering is also observed and discussed. [S0556-2813(97)05310-7]

PA TABLE I. Experimental data used in the present analysis of α and ^{3}He-particles elastic scattering on ^{12}C and ^{16}O nuclei.

Reaction	$\alpha+{}^{12}$C							$\alpha+{}^{16}$O						
E_{lab} (MeV)	54.1	90	104	139	145	166	172.5	32.2	40.4	54.1	65	80.7	104	146
Ref.	[5]	[10]	[26]	[27]	[9]	[28]	[9]	[11]	[11]	[5]	[29]	[11]	[26]	[11]
Reaction	^{3}He$+{}^{12}$C							^{3}He$+{}^{16}$O						
E_{lab} (MeV)	27.4	41	72	82.1	98	119	217	25	33.3	40.9	60			
Ref.	[30]	[30]	[31]	[32]	[10]	[33]	[34]	[35]	[36]	[37]	[38]			

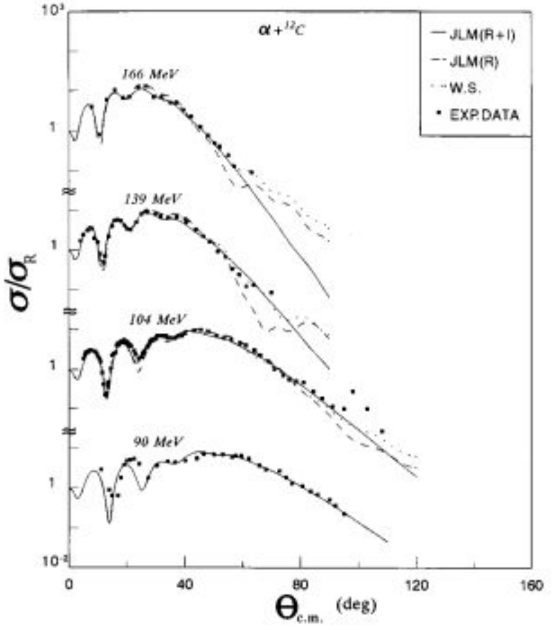

FIG. 1. The differential cross sections as ratio to Rutherford, for the elastic scattering of α particles on ^{12}C reaction at $E^{\alpha}_{lab}=90$, 104, 139, and 166 MeV reproduced by JLM(R+I), JLM(R), and WS potentials, compared with the experimental data taken from references shown in Table I. For DF potentials the density dependent sets of parameters given in Table II for JLM(R) and Table III for JLM(R+I) are considered. Solid curves are JLM(R+I), dashed curves are JLM(R), and dotted curves are WS calculations.

Khallaf, S. A. E. Amry, A. M. A. Mokhtar, S. R. “Elastic scattering analysis of α and 3 He particles on 12 C and 16 O using a complex folded potential”. Phys. Rev. C, 1997.

Estado del Arte

Within the SMDOM the optical potential (OP) is taken in the form

$$\mathbf{V}(r) = V_{\mathrm{Coul}}(r) - V_F(r, E) - V_P(r, E) - iW(r, E). \quad (1)$$

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Large-angle α-particle scattering on ^{12}C and search for signatures of α-particle Bose condensation

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Evidence of the 3α-particle condensate character of the Hoyle state (the 0_2^+ state at 7.65 MeV in ^{12}C) implies not only an enhanced radius of ^{12}C in this state, which was established by many theoretical calculations and confirmed by the recent diffraction model analysis, but also zero relative angular momenta between clusters. We performed coupled-channels model calculations of the angular distributions of $\alpha + {}^{12}$C elastic and inelastic (to the 4.44-MeV 2^+, 7.65-MeV 0_2^+, and 9.65-MeV 3_1^- states) scattering at 110 MeV and found the ratio of the empirical spectroscopic factors $S(L)$. As the differential cross sections of these reactions are characterized by pronounced enhancement and strong oscillations at large angles, we assumed a potential scattering in the forward hemisphere and the direct transfer of a ^{8}Be cluster at $\theta_{c.m.} > 90^\circ$ and took into account the direct transfer of ^{8}Be in the ground state and in the first excited 2^+ and 4^+ states. We found that the cluster configuration with $L = 0$ dominates in the 0_2^+ state, being more than three times larger than that in the ground state. This result provides additional evidence of the condensed structure of the Hoyle state in ^{12}C with a dominance of zero relative angular momentum. The negative-parity 3_1^- excited state in ^{12}C observed above the 3α threshold is also considered to have the 3α-cluster structure. The present calculations described well the structure of the large-angle cross section on this state. We found a positive interference for all allowed $\alpha + {}^8$Be configurations with a dominance of the p-orbital (69%) $\alpha + {}^8$Be motion and confirmed the exotic, but hardly a condensed, structure of this state.

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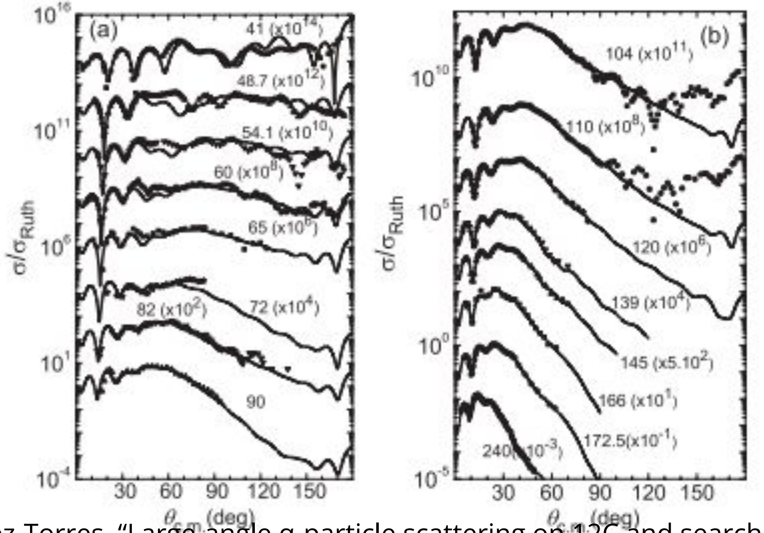
FIG. 1. The elastic angular distributions from $\alpha + {}^{12}$C scattering at (a) $E_{\mathrm{lab}} =$ 41–90 MeV and (b) $E_{\mathrm{lab}} =$ 104–240 MeV calculated within the SMDOM method (curves) in comparison with the experimental data (shapes) [28].



T. L. Belyaeva, A. N. Danilov, A. S. Demyanova, S. A. Goncharov, A. A. Ogloblin, and R. Perez-Torres. “Large-angle α-particle scattering on 12C and search for signatures of α-particle Bose condensation”. Phys. Rev. C, 2010.

Estado del Arte

Elastic scattering analysis of isobar nuclei $A = 6$ projectiles on ^{12}C using different models of optical potential

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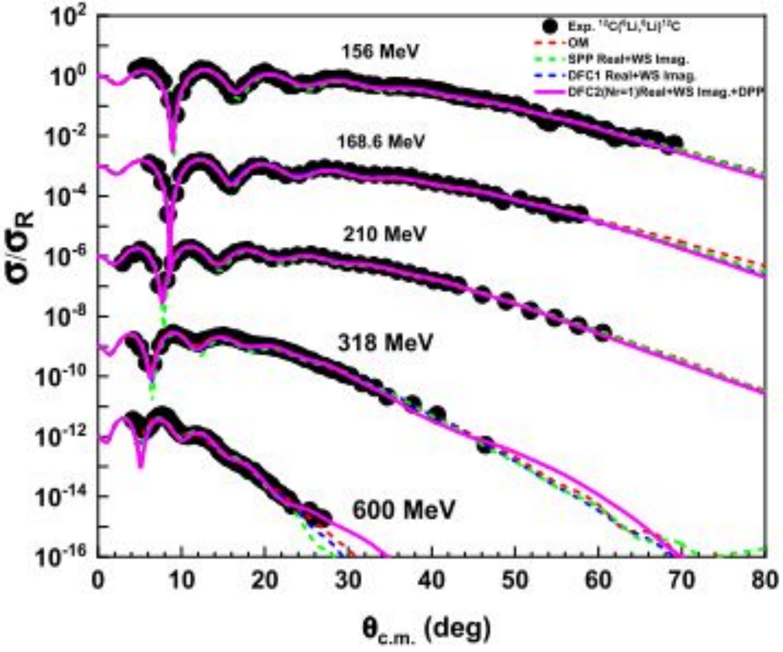
Abstract

In this research, we have extracted a new systematic global description for the fifteen data sets of the $^6Li+^{12}C$ elastic scattering angular distribution in the energy range of 5.8–600 MeV, and for the seven data sets of the $^6He+^{12}C$ elastic scattering in the energy range of 5.9–493.8 MeV using the simple optical model OM potential with fixed radii parameters. We have reanalyzed the two nuclear systems using a microscopic method within the framework of the double folding São Paulo potential (SPP) and the double folding cluster model (renormalized DFC1 and non-renormalized DFC2), prompted by the cluster structure of both (^6He and ^6Li) nuclei. We have adding the dynamic polarization potential (DPP) to DFC2, for well reproducing the experimental data, because the elastic scattering of weakly bound nuclei (^6He and ^6Li) is strongly affected by the coupling to other reaction channels, such as break-up. We have studied the effect of hallo properties of ^6He by comparing the reflexion coefficients derivatives and the reduced cross sections (*according to different prescriptions*) of the two projectiles. The energy dependence for the reaction cross sections σ_R, real and imaginary volume integrals of the considered reactions and comparing it to the previously reported ones have been investigated. The dispersion relation between real and imaginary parts of optical potential has been investigated for both studied systems.



Ahmed Hammad Amer, Yu.E. Penionzhkevich. "Elastic scattering analysis of isobar nuclei A = 6 projectiles on 12C using different models of optical potential". ScienceDirect . Nuclear Physics A, 2021.

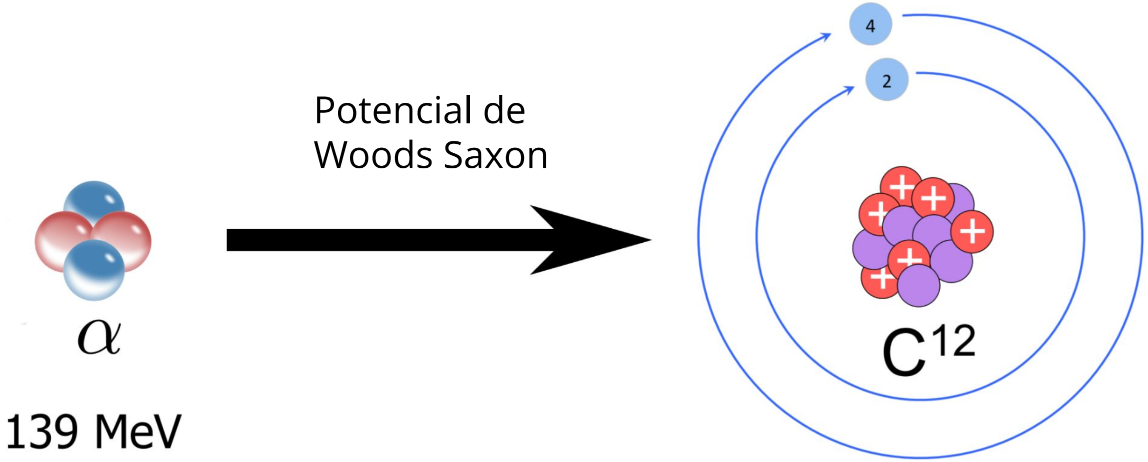
Problema

Los potenciales complejos son raros y pocos estudiados en el pregrado de física, sin embargo, estos potenciales son interesantes y útiles ya que pueden modelar colisiones con resonancia.

Este tipo de potenciales son capaces de modelar reacciones elásticas e inelásticas entre núcleos, en particular la colisión del núcleo 12C y partículas alfa. En esta colisión se encuentra que a partir del análisis del modelo óptico de los datos elásticos se tiene que la parte real e imaginaria del potencial de interacción es de tipo Woods Saxon con 6 parámetros libres.

Problema

¿Es el uso de un potencial complejo óptico una buena aproximación para modelar la colisión elástica entre el núcleo 12C y partículas alfa?



Objetivos

General:

Estudiar teóricamente y computacionalmente la colisión entre los núcleos alfa y carbono 12 con energía de 139 MeV .

Específicos:

- Realizar explícitamente el desarrollo teórico, aplicando el modelo óptico a la colisión elástica del sistema.
- Solucionar la ecuación de Schrodinger con un potencial complejo usando métodos numéricos.
- Reproducir la gráfica de la dispersión elástica.
- * Profundizar en los sistemas inelástico y de reacción nuclear, donde es necesario *
- * Simular la colisión elástica utilizando el software Geant 4*

Gracias