THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

Laboratory of Theoretical Physics

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Let $f(v')$ be an arbitrary function ~~function~~ of destribution of nucleons of nuclei in momentum space isotropic at angles. Let us approximate the cross-section of free particle interaction of the particle and nucleon considered by the product of $\frac{1}{V^2}$ by some polynomial, ie. $\sigma(V) = \frac{1}{V^2}\sum_{k=0}^{P} B_k V^k$.

Then the influence of intranucleear motion on the interaction will formally show itself in changing the polynomial coefficient. An evident form of these coefficients is given below for the general case.

For each kind of particles interacting with the nucleons of the nucleus, an energy interval can be found in which the particles suffer, in general, pair interactions with nucleons of target nucleus.

Then we can consider in some approximation the nucleus as a matter in which the particle motion can be expressed by a kinetic equation (when there are no sources inside the nucleus):

$$\vec{V}\,\nabla n + |V_1|\frac{n}{\ell} = 0, \qquad (1)$$

where n is the function of distribution of particles interatting with the nucleus,

$\vec{V}$ is the velocity of the particles hitting the nucleus.

$|V_1|$ is the module of relative velocity of the interacting particles.

ℓ is a mean free range.

The equation (1) may be easily written as follows:

$$\vec{K}\,\nabla n + \frac{n}{\ell_{ef}} = 0,\quad \vec{K} = \frac{\vec{V}}{V} \qquad (2)$$

which coincides in form with the kinetic equation describing the probogation of the particles through the nuclear matter at rest.

As it follows from (1) and (2) in supposition that the function of distribution of nucleons of the nucleus in the phase space $N(\vec{x},\vec{V}') = N(\overset{\circ}{\vec{x}})f(\vec{V}')$ the cross-section of the interaction considering the effect of intranuclear probogation is equal to

$$\sigma_{ef}(V)=\frac{1}{V}\int_{\Omega} f(\vec{V}')\sigma(|\vec{V}-\vec{V}'|)|\vec{V}-\vec{V}'|d\vec{V}'. \qquad (3)$$

Let us write (3) in spherical system of coordinates. Making use of the fact that $f(\vec{V}')$ is isotropic at angles and the cross-section of the interaction is azimuthally symmetrical; we can perform integration over angles θ and φ and get

$$\sigma_{ef}(V)=\frac{2\pi}{V^2}\sum_{K=0}^{P}\frac{B_K}{(K+1)}\sum_{m=0}^{K+1}C_{K+1}^{m}\left[1-(-1)^{m}\right]V^{K-m+1}\int_{\Omega} f(V')V'^{m+1}dV'. \qquad (4)$$

The expression (3) includes the module of relative velocity. The sign of this module may be omitted if (a) $V > V'$ throughout the whole region of integration (in case of Fermi distribution, for example) or, if (b) K is odd for V' unlimited in the integration region (in case of Gauss distribution, for example). We suppose, that one of these restrictions is performed.

Expression (4) may be easily written:

$$\sigma_{ef}(V)=\frac{1}{V^2}\sum_{\ell=0}^{P}\left\{2\pi\sum_{K=0}^{P}\frac{B_K}{(K+1)}C_{K+1}^{\ell}\left[1-(-1)^{K-\ell+1}\right]\int_{\Omega} f(V')V'^{K-\ell-2}dV'\right\}V^{\ell}. \qquad (5)$$

Let us consider two particular cases:

1) Fermi distribution and

2) Gauss distribution.

1. For Fermi distribution the function $f(V')$ is determined considering the conditions of normalization as follows:

$$f(V') = \begin{cases} \dfrac{3}{4\pi V_0^3} & \text{inside the volume } \Omega \\ 0 & \text{outside the volume} \text{ —"—} \end{cases} \qquad (6)$$

Then the effective cross-section may be written

$$\sigma_{ef}(V,V_0)=\frac{1}{V^2}\sum_{\ell=0}^{p}\left\{\frac{3}{2}\sum_{k=0}^{p}\frac{B_k}{(k+1)}C_{k+1}^{\ell}\left[1-(-1)^{k-\ell+1}\right]\frac{V_0^{k-\ell}}{k-\ell+3}\right\}V^{\ell}. \qquad (7)$$

2. For Gauss distribution the function $f(V')$ considering the conditions of normalization is equal to:

$$f(V')=\frac{a^3}{\pi\sqrt{\pi}}\,e^{-a^2V'^2} \qquad (8)$$

where a is Gauss distribution parameter.

As it was noted above the cross-section of interaction in this case is approximated by the product of $\frac{1}{V^2}$ by the polynomial to the odd power of velocity. The effective cross-section of interaction for this case is equal to:

$$\sigma_{ef}(V,a)=\frac{1}{V^2}\sum_{\ell=0}^{p}\left\{\sum_{n=0}^{p}\frac{B_{2n+1}}{(2n+2)}C_{2n+2}^{2\ell+1}\frac{(2n-2\ell+1)!!}{(2a^2)^{n-\ell}}\right\}V^{2\ell+1}. \qquad (9)$$

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