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MATRIX ELEMENTS IN NUCLEAR SHELL THEORY

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Abstract: In a previous paper, transformation brackets for harmonic oscillator function were defined and used for the evaluation of matrix elements for nuclear forces. Numerical tables for the transformation brackets are now available. The purpose of this paper is to show how these tables, combined with those given in the present note, can be used to evaluate the matrix elements of nuclear shell theory directly in terms of Talmi integrals. For comparison between present methods and those used previously, a relation between Slater coefficients and Talmi integrals is also obtained.

1. Introduction

In a recent paper [1]) (to be referred to as I), one of us (M.M.) defined and gave explicit expressions for the transformation brackets for harmonic oscillator functions. These transformation brackets have been tabulated numerically [2]) by one of us (T.A.B.). The purpose of this paper is to show how these tables, combined with those given in the present note, can be used to evaluate the matrix elements of nuclear shell theory directly in terms of Talmi [3]) integrals.

We start by giving the definition of the transformation brackets. If we have a particle in an harmonic oscillator potential, its wave function is

$$\Re_{nl}(r)Y_{lm}(\theta, \varphi), \tag{1}$$

where $Y_{lm}(\theta, \varphi)$ is a spherical harmonic and $\Re_{nl}(r)$ is the radial function. Taking, as in I, r in units of $(\hbar/m\omega)^{\frac{1}{2}}$, the radial function has the form

$$\Re_{nl}(r) = r^l \exp\left(-\tfrac{1}{2}r^2\right) \sum_{k=0}^{n} (a_{nlk} r^{2k}), \tag{2}$$

where

$$a_{nlk} = \left[\frac{2(n!)}{\Gamma(n+l+\frac{3}{2})}\right]^{\frac{1}{2}} \binom{n+l+\frac{1}{2}}{n-k} \frac{(-1)^k}{k!}, \tag{3}$$

and Γ stands for a gamma function. The two-particle wave function with total angular momentum λ is then given by

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