THE DENSITY MATRIX EXPANSION FOR THE HEAVY ION OPTICAL POTENTIAL

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In a previous work[1] we have introduced a complex Skyrme-type interaction to be used for the calculation of the heavy ion optical potential. Its real and imaginary parts were related through a scaling factor evaluated at the local density ρ and kinetic energy density $\tau^{(2)}$. This factor was found numerically from a finite range complex effective interaction[2] derived from nuclear matter calculations appropriate for heavy ion collisions. The Skyrme-type interaction gives rise to a complex energy functional.

In the present work we derive a complex energy functional directly from the complex effective interaction of Ref. 2 by using the density matrix expansion of Negele and Vautherin[3]. We find the explicit dependence on ρ and $\tau^{(2)}$ of the functional proposed in Ref. 1. The potential energy density H_{pot} of a finite range interaction can be expressed as :

$$H_{pot} = A+B\tau^{(2)}+C|\nabla\rho|^2+D\nabla^2\rho$$

where A, B, C and D are defined in terms of the effective interaction and in our case are complex quantities. We fit them with polynomials in ρ up to 5th degree. For the imaginary part we have to introduce an extravariable X related to $\tau^{(2)}$ by

$$X = \frac{\tau^{(2)}-\tau^{(2)}_{min}}{\tau^{(2)}_{max}-\tau^{(2)}_{min}}$$

where $\tau^{(2)}_{min}$ and $\tau^{(2)}_{max}$ are the extreme values of the kinetic energy densities associated to the deformed Fermi sea used in the nuclear matter calculations. It turns out that with 3rd degree polynomials in X , we can reproduce the exact imaginary parts of A, B, C and D within 3 %. This fit is perfectly consistent with the previous work[1].

The potential calculated from E_{pot} reproduces well the exact results[4] derived from the complex finite range interaction for the system $^{16}O+^{16}O$

References

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