Pramāṇa – J. Phys., Vol. 35, No. 3, September 1990, pp. 325–328. © Printed in India.

Density of quarks in heavy spherical nuclei using NRQSM

NAZAKAT ULLAH
Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005, India

MS received 17 March 1990

Abstract. A nonrelativistic quark shell model (NRQSM) is used to derive an expression for the density of quarks in heavy spherical nuclei. It is shown that quark density is related in a simple way with the probability of finding a nucleon in a nucleus. The quark density is used to determine the ratio of average distance between two quarks to the average distance between two nucleons.

Keywords. Quark density; shell model; cluster model.

PACS No. 21·60

One of the most important aspects of a many-body system is to study its various properties starting from its basic constituent particles. As our knowledge of the particles which are used to build a nucleon advances, we get more and more interested in building a theory of nucleus starting from this basic picture. As a first step in this direction we would like to show how we can derive an analytic expression for the density of these constituent particles in a heavy spherical nucleus. We shall do this using non relativistic quark shell model (NRQSM).

Let us consider a nucleus of mass number A, then its wave function using NRQSM can be written as

$$\Phi = \int \mathscr{A}\left[\prod_{i=1}^{A} \chi_{i,c=0,s=\frac{1}{2},m_{s_i},I=\frac{1}{2},m_{I_i}}(\bar{\rho}_i, \bar{\lambda}_i)\,\phi_{n_i l_i m_{l_i}}\left(\frac{1}{3}\sum_{k=0}^{2} \bar{r}_{i+k}\right)\right]\delta(\bar{R})\,\mathrm{d}\bar{R}, \tag{1}$$

where

$$\bar{R} = \sum_{i=1}^{3A} \bar{r}_i, \tag{2a}$$

and χ_i denotes the internal wave function of a nucleon consisting of three constituent quarks. It is an antisymmetric wave function having colour quantum number $c = 0$, spin $s = \frac{1}{2}$, projection of spin m_{s_i}, isospin $I = \frac{1}{2}$ and projection of isospin m_{I_i}. The radial part consists of two Gaussian wave functions

$$\left(\frac{2}{3\pi b^2}\right)^{3/4}\left(\frac{2}{4\pi b^2}\right)^{3/4} \exp\left(-\frac{\rho_i^2}{4b^2} - \frac{\lambda_i^2}{3b^2}\right), \tag{2b}$$

b, being the harmonic oscillator parameter, and $\bar{\rho}_i = \bar{r}_i - \bar{r}_{i+1}, \bar{\lambda}_i = \bar{r}_{i+2} - \frac{1}{2}(\bar{r}_i + \bar{r}_{i+1})$. The wave function $\phi_{n_i l_i m_{l_i}}$ is the centre-of-mass wave function of ith nucleon having quantum numbers n_i, l_i, m_{l_i}. The integration over δ function takes care of the