### 9.9 Interactions in quantum quasishrunk space

## **9.9.1 Reference parameters for the quantum quasishrunk space**

In order to understand the physical aspect of the quantum vibrational conditions for molecules, we have to analyse some aspects of the motion from a point of view of the quantum quasishrink space.

The plot of Eq. (9.26) shown in Fig. 9.28 shows that the vibrational range is negligible, when estimated by the external length units. Although, Eq. (9.26) still defines a finite distance change  $\Delta r$ for any  $\Delta$ . So the intrinsically small value of  $\Delta r$  still could be used as a parameter addressing the respective energy levels. Then we may use this parameter as a quantum parameter. For H<sub>2</sub> molecule it is given by Eq. (9.26) and for D<sub>2</sub> - by Eq. (9.28).

The quantum rotational - vibrational motion could be presented by the symbolic plot shown in Fig. 9.31.



Fig. 9.31 Symbolic plot of the vibrational rotational motion

The range of  $\triangle$  is shown by contour lines. The close spaced lines indicate the lowest energy level. This is inverse to the QM model. The plot is called symbolic for two reasons:

- the vibrational range of  $\Delta$  is magnified enormously in comparison to the internuclear distance.

- the radius *r* is a half of internuclear distance, but it could be normalized to the internuclear distance, for convenience.. We may refer it as a radius vector of the symbolic plot.

- the stroboscopic trace with elliptical shape will be explained later

Analysing the possible transitions between the vibrational levels in the simultaneous rotational and vibrational motion, we see that the radius vector may not pass through the equilibrium. Instead, it may jump to a lower point of the opposite side with emission of the energy difference. From a point of view of the IG fields potential balance, it is not possible the vibrations to be only from one side of the equilibrium. This is a apparent from the energy balance discussed in §9.7.4 and Eq. (9.23). So a possible passing between same energy levels residing on both side of the vibrational ladder could be also possible. Only by this feature, some molecular states exhibiting a long radiation lifetime could be explained.

It is reasonable to consider that a relation between the rotational and vibrational frequencies exists. From the symbolic plot it is evident that if their periods are equal, the positional molecular momentum is not balanced in respect to the stationary frame. When the rotational period is equal to two vibrational periods, it is balanced. In this conditions one rotational period corresponds to a  $2\pi$  cycles of the radius vector of the symbolic plot, while the vibrational one - to one half or  $\pi$ . Then for the analysis of the vibrational motion, a one half or one forth of the symbolic curve could be used.

#### 9.9.2 Vibrational level Quantum zone range

Despite considering the vibrational energy levels as fixed, the distance between them may allow additional small quantum levels. It is equivalent to consider that vibrational levels exhibit a small change as a result of some quantum interactions.

The energy range of any vibrational level could be presented as a difference between two consecutive neighbouring levels. Let assuming that due to the self adjusting internuclear distance, the shape of the orbits for H<sub>2</sub> and D<sub>2</sub> is not changed, so the parameter  $a = \sqrt{2} = \text{const}$ . The corresponding distance change then will be proportional to the change of the orbit length. Let consider the case when the molecule possesses a lowest vibrational

rotational energy. Then it is in a vibrational level 0, corresponding to the equilibrium. Now suppose the molecule is activated to the neighbouring level 1. The distance change in quantum length units is

$$\Delta r(1) - \Delta r(0) = \Delta L_q \text{ (m)}$$
(9.29)  
The corresponding fractional change is  
$$\Delta L_q/L_q = 8.908 \times 10^{-9} = \delta$$
(9.30)

Now we have to look for a similar change of some basic parameter related with frequency.

It is reasonable to look for a possible change of some CL space parameter with a dimension of frequency. More appropriately we may examine the fractional change of some frequency, when changing the proper number of cycles with one.

The possible CL space related parameters with frequency dimensions are the following:

- the proper frequency (a) of the electron shell-positron:  $v_c$ 

- the proper frequency (b) of positron-core:  $3v_c$ 

- number of cycles of oscillations of (a) and (b) frequency in one orbital quantum time: 56335 and 169005 respectively

- number of resonance cycle of CL node (calculated in Chapter 2) :  $N_{RO} = 0.88431155 \times 10^9$ 

The closer value to Eq. (9.30) is

$$1/N_{RO} = 1.1308 \times 10^{-9} = \varepsilon.$$
 (9.31)

This is the fractional NRM frequency change per one SPM cycle. It is reasonable to expect that the quantum condition is defined by the change of the number of the resonance cycles per one SPM cycle (for CL node) because the both parameters - the number of the resonance cycles and the time base for the SPM cycle are naturally defined.

The time base parameter is the time per one cycle of SPM vector, expressed by the Compton time.

In fact the calculated value of Eq. (9.30) is closer to  $\varepsilon$  multiplied by 8.

$$8\varepsilon = 0.90466 \times 10^{-9} \tag{9.32}$$

Combining Eq. (9.29) and (9.30) we may express the quantum conditions for any neighbouring levels

$$\frac{\Delta r(\Delta+i) - \Delta r(\Delta)}{L_q} = \delta_i$$
(9.33)

where:  $i = \Delta + 1$ 

In a similar way the proportionality of condition (9.32) applied for different level spacing may be expressed as

$$\varepsilon_i = 2i(4\varepsilon)$$
 for H<sub>2</sub> molecule (9.34)

 $\varepsilon_i = i(4\varepsilon)$  for D<sub>2</sub> molecule (9.34.a)

Equation (9.33) can be applied for  $H_2$  and  $D_2$  molecule, while their  $\varepsilon_i$  parameters are different.

Equations (9.33) and (9.32) calculated for 1 < i < 18) (for H<sub>2</sub>) are plotted in Fig. 9.32.



Fig. 9.32 Correlation between the fractional change of the quantum length and NRQ frequency for  $H_2$  -ortho-I molecule

A similar plots for  $D_2$  ortho-I molecule are shown in Fig. 9.32.A.

The plots for H<sub>2</sub> and D<sub>2</sub> molecules show the periodicity match between  $\delta_i$  and  $\varepsilon_i$ , with a same common parameter  $i = \Delta + 1$ . Consequently, the quantum conditions are defined by the stroboscopic match of the IG fields balance with the CL space parameter N<sub>RQ</sub>. In the same time, the periodicity between  $\delta_i$  and  $\varepsilon_i$  determines the widths of the vibrational zones.



Fig. 9.32.A Correlation between the fractional change of the quantum length and NRQ frequency for  $D_2$  ortho-I molecule

The plots of  $\delta_i$  and  $\varepsilon_i$  show departure for a larger i ( $\Delta$ ). The departure is smaller for D<sub>2</sub>. This means that the IG fields balance for D<sub>2</sub> molecule is fulfilled for larger quantum numbers  $\Delta$  in comparison to the H<sub>2</sub> molecule.

Equations (9.34) for H<sub>2</sub> and (9.34.a) for D<sub>2</sub> for i = 1 ( $\Delta = 0$ ) provide the limit of the lowest (zero) level zone. They both have a periodicity of  $4\epsilon$ , while  $\epsilon$  itself defines the limit.

The zero zone range for  $D_2$  obtained by Eq. (9.27), is 0.007284236 eV. Dividing the zone range by the periodicity 4 we get: 1.821E-3 eV. Converted directly to wavenumbers it is 14.6878 cm-1. This is very close to the rotational constant  $B_e = 14.66 \text{ cm}^{-1}$ , determined by Cunningam and Dieke, (1950) and cited in *http://webbook.nist.gov/chemistry*.

Consequently, the obtained value is a result of direct CL space pumping by fundamental frequency set. So it is calculated by the theoretical equation:

$$B_e = \frac{[E_V(1) - E_V(0)]q}{4hc10^2} = 14.6878 \text{ cm}^{-1}$$
 (9.35)

Now the physical sense of the fundamental molecular set becomes apparent. It could be presented as a classical resonance with a finite range, but strobed by the allowed quantum conditions defined by the  $\varepsilon$  parameter, given by Eq. (9.31). In this aspect, the rotational constant is the wavenumber of the directly pumped and emitted photon in the zero zone of the vibrational curved.

## **9.9.2** Cross verifications of the vibrational rotational parameters of $\mathbf{H}_2$

A. For the H<sub>2</sub> molecule, the zero zone range is 0.013822 eV and the Eq. (9.35) provides a value of 27.87 cm<sup>-1</sup>. This value is quite close to the value B<sub>e</sub> = 27.30 cm<sup>-1</sup>, given by Dieke and Blue, (1935) and Dieke (1958) cited in the NIST data (the same website, as given above). Different experiments show a variation in about 4 cm-1. The consideration for the selected above experimental value are discussed in §. ...

**B**. The "fundamental frequency" calculated by QM is 4159 cm-1 (D. A. McQuarrie, Quantum chemistry, (1983)). This value corresponds to a fre-

quency calculated by Eq. (9.A.3). Applying the BSM correction according to Eq. (9.A.4) (multiplying by  $(\mu_p/\mu_e)^{0.5}$  we get a corrected value of 55.82 cm<sup>-1</sup>. This should be the equivalent molecular frequency according to BSM concept. The obtained value **appears very close to twice the theoretical value of 27.87 cm<sup>-1</sup>**, determined by the methods of the quantum mechanics.

 $27.87 \times 2 = 55.74 \text{ cm}^{-1}$ .

**C.** The equivalent molecular frequency could be approximately determined by the maximum of the envelope of the rotational curve, given by QM equation (9.A.7). Really, for temperature about 77 K, the maximum is very close to twice J number giving the same value as in case B.

**D.** Relation between the vibrational and rotational period and the CL space time constant.

In the end of §9.9.1 a consideration was expressed, that the vibrational and rotational frequency are related by ratio 2:1. Such ratio appeared in case B and C. Let calculate the corresponding cycle periods by the expression:  $T = (c\overline{v}10^2)^{-1}$ . The results are given in Table. 9.4.

Relation between the cycle period of the vibrational and rotational motion of H<sub>2</sub> ortho-I and CL space time constant Table 9.4

Type of motion	ν [cm-1]	T [sec]	<i>T/</i> t <sub><i>CL</i></sub>
Rotational	27.87	1.1969E-12	$0.4933 \approx 1/2$
Vibrational	55.74	0.5984E-12	$0.2467 \approx 1/4$

For  $D_2$  ortho-I molecule the theoretical results are:

 $T/t_{CL} = 0.936$  for rotational motion  $T/t_{CL} = 0.468$  for vibrational motion

The close value of the cycle period to the CL time constant means that strong interactions exist between the molecular oscillations and the SPM vector. The vibrational cycle period of  $H_2$  and  $D_2$  is half of their rotational cycle period. Then the vibrational trace in quantum units will have a shape of ellipse. Such trace may pass through the whole vibrational ladder, while satisfying at the same time the quantum conditions. This means, that the allowed fine energy levels will be influenced by the proper match of the NRQ frequency phase, in a

similar way as the matching curves for  $\delta_i$  and  $\varepsilon_i$ , shown in Fig. (9.32) and (9.33). This is a type of **stroboscopic effect between two systems with different but close periodicity**. (A practical example of such effect is a common motion of mechanical system with periodicity. When such system is illuminated Moire's patterns are observed). The vibrational cycle in such conditions appears as a trace of discrete levels. It is illustrated graphically by blue dots in the symbolic plot shown in Fig. 9.31.

### **9.9.3 Distribution of the quantum transitions along the vibrational trace**

In the Balmer model we found, that the total orbital time approaches the CL time constant  $t_{CL}$ , but is little bit lower, because two quantum conditions then becomes in conflict. The same orbital time conditions should be valid for the molecular bonding orbit and electron. Having in mind that the periods of the two cycles are close to the CL time constant, we may accept, that the start time of CL pumping and photon emission are well distributed, along the vibrational curve, but with some repeatable conditions for their position. At the same time, the rotational angular velocity may be considered as not dependent on the vibrational motion, because practically the internuclear distance estimated by the free CL space is not changed. Then we may derive the relative dependence of the momentum intrinsic energy from the phase of the vibrational motion.

Figure 9.32.B illustrates the trace of the vibrational motion as a symbolic curve.



Fig. 9.32.B

*Note*: The radius vector *r* in the symbolic plot is not proportional to the internuclear distance in free CL space but to some normalized value in the qua-

sishrunk space. In such aspect  $r_{min}$  and  $r_{max}$  are referenced to the quasishrunk length unit

Points A and B are symmetrically situated from the both sides of the equilibrium trace. Although they correspond to one and a same energy (of the vibrational level), they are physically separated.

Here we will consider a balance between two intrinsic energies: the vibrational and the gravitational whose distribution corresponds to:

vibrational energy: by IG(TP) for  $r > r_{ne}$ attraction energy: by IG(CP) for  $r < r_{ne}$ It is more convenient to use the ratio between

 $\mathbf{r}_{\min}$  and  $\mathbf{r}_{\max}$   $k = r_{\min}/\mathbf{r}_{\max} < 1$ 

Let examine the energy distribution in a limited angle of the radius vector around X and Y axes, for example within angle of  $\pm 45^{\circ}$ .

Firstly, we may determine the change of radius vector as a function of angle deviation, but normalised to the corresponding value at the positions A and B respectively:

$$\delta r_A = \sqrt{k^{-2} \sin^2(\theta) + \cos^2(\theta)} \text{ around point A}$$
$$\delta r_B = \sqrt{\cos^2(\theta) + k^2 \sin^2(\theta)} \text{ around point B}$$

The corresponding IG energies are inverse square dependent on the distance change. The normalization of the radius vector for points A and B in fact is justified from the energy point of view. If assuming transitions between the corresponding energy levels and the lowest vibrational level, the energy difference will give the photon energy. So the expressions of the energy envelope of the corresponding spectral line are respectively:

 $E_A = k^{-2} \sin^2(\theta) + \cos^2(\theta)$  for a zone around A (9.36)

 $E_B = 2 - [\cos^2(\theta) + k^2 \sin^2(\theta)]$  for a zone around B (9.36)

The different sign of both energy comes artificially from their referencing to the equilibrium. The factor comes from their normalization about the unity for both energies. The plotted curves of  $E_A$  and  $E_B$  for parameter k = 0.9 are shown in Fig. 9.33.



Fig. 9.33 Shape of the energy envelope of the spectral lines for one band of H2 spectra

The shown plot corresponds to the shape of the energy envelope of the spectral lines from P and R branches for consecutive rotational levels:

 $E_A$  - corresponds to P branch from one band  $E_B$  - correspond to R branch from the same band

The P and R branches of the vibrational-rotational spectra of the ortho-I states of H<sub>2</sub> and D<sub>2</sub> molecules exhibit a similar signature. Figure 9.34 shows the energy position of the lines from the P and R spectral branch of H2 for (0-v) transitions. According to BSM model, there is not a reason for offsetting the J numbers of P and R branch by one. So the both branches are shown with equal start. The data are taken from I. Dabrowski, (1984) (Lyman system  $(B^1\Sigma_u^+ - X^1\Sigma_g^+)$  (0-v")



Fig. 9.34 Energy position of the lines from P and R spectral branches of H<sub>2</sub> for (0-v) transitions.

Fig. 9.34 shows a similar plot for D2 ortho-I state. The spectral data are provided by H. Bredohl and G. Hezberg, (1973).



Energy position of the lines from P and R spectral branches of  $D_2$  for (0-v) transitions.

The comparison between both figures indicates, that the eccentricity of the vibrational trace for  $D_2$  molecule is much smaller. This is a result of the influence of the neutron, which is over the proton saddle. This also shows that the confinement between the vibrational cycle and the SPM vector is larger for  $H_2$ . When examining the lines from the first few vibrational numbers (directly from the spectra), we find that the difference between them for less energetic bands is quite small. For some bands, the trend for the second and even third vibrational number is reversed. This effect is weaker for  $H_2$  but much stronger for  $D_2$ . It appears only for R branch, but never for P branch. The explanation of this effect is the following. For lower vibrational energy, the molecule exhibits a stronger confine interaction with the SPM vector, because of the close proportionality between the vibrational period and the CL time constant. Then a second mode appears in the vibrational trace. This mode is stronger in  $D_2$ molecule because its vibrational trace is with smaller eccentricity. The second mode is illustrated in Fig. (9.36).



Fig. 9.36 Second mode in the vibrational trace

In order to provide some quantitative prove of the stroboscopic effect between  $\delta_i$  and  $\varepsilon_i$ , we can make one additional test with H<sub>2</sub> data: displacing the P from R branches with some  $\Delta J$  until good match of some set is observed. This is done in Fig. 9.37, where the P branches are displaced by  $\Delta J = 3$ 





Test of possible stroboscopic effect between the two sets ( $\delta_i$  and  $\varepsilon_i$ ) by displacement of the P branches in respect to the R branches

#### 9.9.4 H<sub>2</sub> ortho-II state.

This state of Hydrogen molecule has been shown in Fig. 9.4., which is given below again.



Fig. 9.4 H<sub>2</sub> ortho-II state configuration

The sections of the two proton cores are shown as small black circles. The common quantum orbit is consisted of two serially connected first order quantum loops. The two electrons posses an opposite QM spin. The arrows show the trace direction of one electron and simultaneous positions of the two electrons.

Due to the extended shape of the molecule it could vibrate in two possible modes:

- stretching (without bending)
- stretching and bending

The stretching mode is characterized by P and R branches only. The stretching with bending is characterized with P, R and Q branches. The bending causes asymmetrical distortion of the quantum orbit, as discussed in §9.5.7.4.1.

Observations of such spectra is provided by T. Namioka (1964). The data indicated as (B'-X) bands correspond to the first mode, while the data indicated as (D-X) bands - to the second mode. Table 9.4 shows the energy levels of the first J lines from the P and R branches of (0-v) transitions, from (B'-X) bands.

Optical transitions (0-v) of H<sub>2</sub> ortho-II **Table 9.4** 

Transition	First J of R (eV)	First J of P (eV)	hv <sub>av</sub>
(0-0)	13.7	13.683	13.69
(1-0)	13.936	13.92	13.928
(2-0)	14.149	14. 129	14.139
(3-0)	14.338	14.318	14.328
(4-0)	14.498	14.48	14.489
(5-0)	14.616	14.598	14.607
(6-0)	14.652	14.636	14.644
(7-0)	14.664	14.649	14.656
(8-0)	14.672	14.657	14.664

Without plotting the photon energy, it is evident that the larger energy is at (9-0) transitions.

Now let make a simple analysis of the H<sub>2</sub> ortho-II configuration, shown in Fig. 9.4. If accepting that the orbital shape is made of aligned circles and the sections of the proton core are centred in these circles as shown in the figure, the total trace length is:  $3\pi L_p = 6.286327$  A. Dividing on the trace length of the first harmonic quantum loop we obtained ratio of 1.89067. In order this ratio to be equal to the closer integer 2, we have to correct the length by 2/1.89067=1.0578. With the same factor the internuclear distance should be corrected, or:

$$6 \times \frac{L_p}{4} \times 1.0578 = 1.05833$$
 A .

Using this value for internuclear distance as for H2 ortho-I, we get:

$$E = \frac{2q}{4\pi\varepsilon_o 1.05833 \times 10^{-10}} = 27.212 \text{ eV}$$
 (9.28)

Subtracting from this value the photon energy of the largest optical transition (9-0) we get: (27.198 - 14.667)=12.545 eV. The half of this value is 6.272 eV, which is very close to  $E_{BEP}$  for  $H_2$  ortho-I state (6.26 eV), known experimentally and determined theoretically in §9.7.3. This coincidence is confirmation for the correctness of the configuration shown in Fig. 9.31.

The two different modes exhibit different vibrational constants referenced to level v=0. The vibrational constants provided by Namioka, based on the observations are shown in Table 9.4 with identification of the vibrational mode by BSM.

Table 9.5

State	v	observed B <sub>e</sub> (cm-1)	mode according to BSM
$B'^{1}\Sigma^{+}{}_{u}$ $B''^{1}\Sigma^{+}{}_{u}$ $D^{1}\Pi^{+}{}_{u}$ $D'^{1}\Pi^{+}{}_{u}$	0 0 0 0	25.42 25.43 31.14 31.20	stretching only stretching only stretching + bending stretching + bending

The appearance of two different data for every mode according to BSM is a signature of elliptical shape of the vibrational trace in quantum quasishrunk units. The effect discussed in §9.9.3. could be valid also for  $H_2$  ortho-II state.

# **9.10.** H<sub>2</sub> para molecule as a most simple example of diatomic homonuclear molecule with a quasirotational vibration

The quasirotational vibration has been introduced in §9.5.4.1 and additionally discussed in §9.5.7.4. The basic condition for such motion requires the molecule to have at least two electronic bonds. For such bonds two spatially displaced quantum orbits are needed. The simple H<sub>2</sub> para molecule satisfies this conditions. Its configuration has been shown in Fig. 9.5. One distinguishable feature of the para-state is that the electrons do not share a common orbit. It has been pointed out that the quasirotational motion is identified by the Q branches in the optical spectrum. The P and R branches are contributed by the quasilinear bond oscillation, while the Q branch - by the bond acting as a centre of the quasirotational motion. So the first type bond emits (photons) by stretching (shrinking), while the second one - by bending. These functions exchange alternatively between both bonds. So the equilibrium is in the moment, when the polar axes of the two protons are parallel. At the equilibrium point, the orbital energy could not be smaller than this of the first quantum orbit (13.6 eV). So we arrive to the same definition of the system energy as for the H<sub>2</sub> ortho-I state (factor two in the nominator of Eq. (9.10)), but for a nuclear distance defined directly by the length of the quantum orbit. Then the system energy equation of the  $H_2$  para state is:

$$E_{VIP} = \frac{2q}{4\pi\varepsilon_o L_q(1)} = 21.135 \text{ eV}$$
 (2.28)

The Eq. (2.28) shows that the photo-electron spectrum from H<sub>2</sub> para state could not be observed by using the He line of 584 A (21.23 eV). The optical spectrum of this state is known as Werner band or  $C {}^{1}\Pi_{u} \rightarrow X {}^{1}\Sigma_{g}^{+}$  system. Observational data are provided by Dabrowski (1984). The optical transitions of Werner band go to higher energies than the Lyman band. This indicates, that the para state has a higher bonding energy. Without a photo-electron spectrum, however, we can't apply the same method for estimation of this energy, as for H<sub>2</sub> ortho-I state.

# 9.11. Discussion about the bonding energy at equilibrium and the rotational constants of $H_2$ and $D_2$ molecules.

In the previous paragraphs we saw that the different states of the  $H_2$  molecule should have different bonding energies at the equilibrium and different rotational constants Be, referenced to a level zero.

This explains the large variation of the constant Be, calculated by the observed spectra. BSM is mostly interested of the parameters of  $H_2$  and  $D_2$ ortho-I state, as they appear as bonding systems between the atoms in the molecules. For this reason, the evaluated constants are seeded out in order to determine the correct state. To seed out the corresponding value, the following criteria are used:

- the higher energy range of the observed spectrum and its match to the the theoretical calculation of the system energy

- the match between the optical and corresponding photo-electron spectrum (if the latter is available)

- excluding observations, where Q branches appear

The last criterion, for example, excludes number of observations, and they usually provide Be in order of  $30 \text{ cm}^{-1}$ .

One of the correct seeded value is  $B_e = 27.30$  cm<sup>-1</sup>, provided by Dieke and Blue, (1935) and Dieke (1958). It is very close to our theoretically calculated value of 27.87 cm<sup>-1</sup>.

### 9.12. Verification of $C_{IG}$ factor.

The factor  $C_{IG}$  was derived for IG(CP) forces from the analysis of H<sub>2</sub> molecule in §9.7.3 and stands for:  $C_{IG} = G_o m_o^2$  where  $G_o$  is the IG constant participating in the inverse cubic IG law and corrected for CL space asymmetry (the different dimensions of the right and left-handed prisms),  $m_o$  - is the intrinsic mass of the proton (neutron).

## **9.12.1** Binding energy between the proton and neutron in the Deuteron system.

The  $C_{IG}$  factor was theoretically derived and its value adjusted to a high precision by the experimental data for  $H_2$  molecule.

In Cahpter 2 §2.9.6.B it was accepted apriory, that the energy balance between both type of intrin-

sic energies in CL space (associated with the central part of the twisted prism model and its peripheral part ) is expressed by the equation:

$$E_{IG}(TP) = 2\alpha E_{IG}(CP) \tag{9.36}$$

where:  $\alpha$  - is the fine structure constant

The validity of the  $C_{IG}$  factor and the relation between IG(CP) and (IG(TP) energy could be additionally verified, by calculation of the binding energy between the proton and neutron in the Deuteron system. The experimental value of this energy is known with a high precision.

The approach used for calculation of the binding energy is illustrated by Fig. 9.38, where;



Fig. 9.38 Approach used for calculation of the binding energy between the proton and neutron in the Deuteron system

Fig. 9.38 a. shows the real configuration of the Deuteron.

Fig. 9.38 b. provides equivalent model, where the neutron is presented as a mass ring and the proton as a mass bar, both possessing the same intrinsic mass (the intrinsic masses of proton and neutrons are equal). The length of the bar is an equivalent length of the proton, presented in this way.

Fig. 9.38 c. provides additional simplification by presenting the bar as a mass point with a same intrinsic mass and position at proper distance  $x_0$  from the ring position on the axis x. We may estimate the binding energy by the energy of disintegration. i. e. the work done for moving the proton along the x axis to the infinity in respect to the neutron (or vice versa). This is like estimation of a classical potential by integration from some initial value to infinity. So the first assumed consideration is:

**Consideration** (1): The binding energy is equal to the disintegration energy when separating the proton and neutron of deuterium atom by moving the proton from neutron along the axis x.

In the real situation, when a large number of deuterons may exists in a finite space volume, the integration to infinity is not possible. But we will show later that even an integration at very small distance, B, comparable to  $L_{pc}$  is enough for a good estimation of the disintegration energy, because the IG forces fall with the cub of the distance.

One question may arise: Why the mass point M is not in the middle of the ring, but displaced at distance  $x_0$ ?

The possible answer of this question is: When the bar is pulling out of the ring along the x axis, the **IG(TP) interactions are involved**. In this interactions, the pull-out energy for any of differential mass point residing on the right side of the bar is not compensated by insertion of a symmetrical point from the left side. Then we accept considerations (1) and (2), which will become more evident later

The process of bar axial removing could be considered as removing of the two half of the bar in opposite direction.

**Consideration (2)**: Let considering the mass and ring respectively as a linear and curvilinear massive structure. Then their masses are completely defined by their length.

In the following mathematical model, the mass point M and the one dimensional bar are both regarded as a sum of equal number of small differential masses. Then applying consideration (1), the disintegration of the mass point in case c. starting from some initial distance  $x_0$  is equivalent to disintegration of the bar in case b.

The mathematical approach for derivation the distance  $x_0$  is simplified if regarding the ring and the bar as a one dimensional structures according to the consideration (2):

For derivation of the disintegration energy, the gravitational potential is initially derived. The process is clarified by Fig. 9.39.



Fig. 9.39 shows a point of the bar with differential mass  $dm_2$ . Using a classical approach, we derive the gravitational field of unit mass point from the bar as a function of distance x. (a trivial classical problem but for inverse cubic dependence of the attractive force)

$$g_x = \frac{dF}{dm_2} = -\frac{G_o m_1 x}{\left(x^2 + r^2\right)^2}$$
(9.37)

where:  $g_x$  is the axial component of the gravitational field; *r* is the neutron radius,  $G_o$  is the intrinsic gravitational constant, *x* - is the distance of the point  $dm_2$  from the ring centre, *r* - is the ring radius,  $m_1$  is the ring mass

The neutron radius is a double folded torus (protoneutron), so expressed by the proton core length it is:

$$r = L_{pc}/(4\pi)$$
 (9.37.a)

Let use x as a running parameter for integration. According to considerations (2) and (1) we have:

$$dm_2 = \frac{m_2}{L}dx$$
 and  $dF = g_x \frac{m_2}{L}dx$   
 $F = \int_{-L/2}^{L/2} \left| g_x \frac{m_2}{L} \right| dx = 2 \int_{0}^{L/2} \left| g_x \frac{m_2}{L} \right| dx$ 

where: F is the axial IG force for one point of the bar with mass  $dm_2$ ; L - is the mass bar length The solution is:

$$F_{x} = \frac{2G_{o}m^{2}k_{cor}}{L} \left(\frac{1}{2r^{2}} - \frac{2}{L^{2} + 4r^{2}}\right)$$
(9.38)

where: 
$$m^2 = m_1 m_2$$

 $k_{cor}$  - is a correction factor, that will help to find how the final solution depends on *L*, for which the possible range is known.

For the mass point *M* at distance  $x_o$  (case c. of Fig. 9.32) we have:

$$F_{x} = G_{o}m^{2} \left(\frac{x}{\left(x_{o}^{2} + r^{2}\right)^{2}}\right)$$
(9.39)

Equating Eq. (9.38) and (9.39) we get expression in which the parameters  $G_o m^2$  are eliminated but its analytical solution for  $x_0$  is difficult. For this reason we make a function of differences of the therms

$$f(x_o) = \frac{x_o}{\left(x_o^2 + r^2\right)^2} - \frac{2k_{cor}}{L} \left(\frac{1}{2r^2} - \frac{2}{L^2 + 4r^2}\right)$$
(9.40)

It is reasonable to expect, that L will be in the range of  $L_p$  or  $L_{pc}$ . For  $L = L_p$  and  $k_{cor} = 1.9246$ , the solution is

$$x_o = 0.0747 \times 10^{-10} \text{ m}$$
 (9.40.a)

The function  $f(x_o)$  falls very sharply for this value. The plot is shown in Fig. 9.34. (9.41)



For different L in the above mentioned range, it still exhibits very well defined minimum. The position of the minimums on the x scale are not very dependent on the introduced parameter  $k_{cor}$ . For the defined range of L, the second term does not influence the  $x_o$  parameter. Then the binding energy could be determined by using the simple case c. of Fig. 9.32, where the ring mass is the intrinsic neutron mass and the point mass M is the proton one.

The estimation has to be in a CL space environments, so let trying to use the IG(TP) energy. Having in mind the relation (9.36) and using the field expression (9.37), which is valid for this case we get:

$$E_{IG}(TP) = (2\alpha) 2 \int_{x_0}^{\infty} C_{IG} \frac{x}{(x^2 + r^2)^2} dx$$
(9.42)

where:  $\infty$  in fact is some finite value little bit larger than  $L_{pc}$  (because the IG forces fall quite fast with the distance).

The factor 2 in front of the integral comes from the two arm branches (along *abcd* axes) of the CL space cell unit. The same factor of 2 has been used in Eq. 9.13 in §9.7.3 for derivation of  $C_{IG}$  factor.

The binding energy is obtained for initial value of  $x = x_o$ . Substituting Eq (9.40.a) into (9.42) and dividing on electron charge q we obtain the **binding energy** in eV.

$$E_{IG}(TP) = \frac{2\alpha C_{IG}}{(x_o^2 + r^2)q} = 2.145 \times 10^6 \text{ (eV)}$$
 (9.42)

where: r is given by Eq. (9.37.a)

The experimentally measured value is  $2.22457 \times 10^6$  eV. Consequently, theoretical derived binding energy is quite close, which is one additional validation for the correctness of the unveiled structures of the proton and neutron.

### **9.12.2** Estimation of the distance between the neutrons in the nucleus of Tritii.

We will show approximate method for estimation of the binding energy from which the approximate value of the neutron separation could be obtained. The Tritii is a three body system with configuration shown in Fig. 9.41.



Fig. 9.41. Nuclear configuration of Tritii

The experimentally determined binding energy is:

 $E_T = 8.4818 \text{ MeV}$ .

According to the analysis in the previous paragraph, we may regard it as a disintegration energy. We may assume apriory, that the distance  $\Delta$  between the two neutrons is few times smaller than the proton length. In the same time, they will be kept apart by the proximity electrical fields of their external shells. So we may regard the two neutrons as separate systems. Since the electrical field energy is part of the IG field energy, we may consider that the total disintegration energy is a sum of two partial disintegration energies.

The disintegration energy between the proton and neutron system could be obtained in a similar way as for deuteron, but considering a ring with twice larger intrinsic mass. We shall use again the theoretically derived Eq. (9.42). but multiplied by factor of two (because two neutrons IG masses are involved instead of one). So the first partial disintegration energy is:

$$E_{IG}(TP) = \frac{4\alpha C_{IG}}{(x_o^2 + r^2)q} = 4.29 \times 10^6 \text{ (eV)}$$
 (9.43)

The second partial disintegration energy then is:

8.4818 - 4.29 = 4.1918 MeV

The obtained energy of 4.1918 MeV will serve to determine  $\triangle$ . We may simplify the task by regarding the two neutrons as two mass points at distance  $\triangle$ . Let consider the following possible options:

(1) - only IG(TP) fields are involved in the separation energy

(2) - only IG(CP) fields are involved in the separation energy

-(3) - both IG(TP) and IG(CP) fields are involved The energy expressions for the both types IG fields are obtained by integration the IG field from Δ to infinity and using the relation (9.36). So we may assign the energy 4.1918 MeV either to (CP) or (TP) and see what reasonable value of Δ we may obtain.

 $\frac{C_{IG}}{2\Delta^2 q}$  = 4.1918 (MeV) if IG(CP) energy - then use (9.44)

 $\frac{\alpha C_{IG}}{\Delta^2 q} = 4.1918 \text{ (MeV) if IG(TP) energy - then use} \quad (9.45)$ 

The calculated distance in angstroms for both cases is respectively:

when considering  $E'_{IG}(CP)$  field: 0.885 A when considering  $E'_{IG}(TP)$  field: 0.107 A

The distance 0.888 A is not acceptable, because it is larger than the proton length. Consequently only the  $E_{IG}(TP)$  field is involved in the balance and the distance is:

$$\Delta = 0.107 \times 10^{-10} \text{ m.}$$
 (9.46)

The neutron separation distance is about 16% of the proton length.

The obtained result shows one important fact: despite its neutrality the two neutrons are well separated by the IG(TP) field. This is one additional confirmation, that the neutron has a proximity Efield, which is kept locked by the IG(CP) forces, but is effective at close proximity. This concept is in agreement with the neutron's possession of magnetic moment.

## **9.12.3** Role of the IG(TP) field in the spatial order of hadrons in the atomic nucleus

The calculated binding energy of Deuteron is valid only if the disintegration is done along the proton long axis and the neutron plane is normal to this axis. If these two conditions are not taken into account the calculated energy will be different. The analysis shows, that the IG(TP) field is only involved. The result for the neutron separation in Tritii also indicates the involvement of the same type of field and interactions. Consequently the IG(TP) fields and the interactions between the CL space and the internal RL(T) of the FOHSs are responsible for the spatial order of the neutrons and protons in the atom. This also means that in any combination of protons and neutrons, the distance between the helical structures is always larger than some critical distance. This preserves these structure and consequently the stable elementary particles from destruction (see §6.4.2 and Fig. 6.1, Chapter 6). This effect is so strong that the hadrons (proton or neutron) does not approach below the critical distance even in the process of atomic synthesis in the stars. Otherwise the FOHSs could crush, which means that enormous flux of hardware neutrino would be observed from the Sun (while we have a lack of expected neutrino flux from the Sun).

The IG(TP) fields allows also the protons to have a limited freedom mainly in the polar atomic plane. This is important condition for integration of the atoms into molecules by EB bonds.