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Title: **PRELIMINARY STATISTICAL ANALYSIS OF THE PROJECTION OF THE VELOCITY OF THE HYDROGEN MOLECULE USING A NOMOGRAM**

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PRELIMINARY STATISTICAL ANALYSIS OF THE PROJECTION OF THE VELOCITY OF THE HYDROGEN MOLECULE USING A NOMOGRAM

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Annotation: This article provides an initial statistical analysis of the projection of the velocity of the hydrogen molecule. Checked for normal distribution according to signs of conformity. In it, Kolmagorov's sign, $\mathcal{X}^2$ (xi - squared) sign, ω^2 - sign and other signs were checked for normalcy. We examined the normality of the general set related to the projection of the velocity of the hydrogen molecule in 7 different ways, and in all cases concluded that the H_o hypothesis was correct.

Key words: Kolmagorov's sign, $\mathcal{X}^2$ (xi - squared) sign,, ω^2 - sign, sample extraction, μ^* absolute central moment, S^{2*} corrected sample variance.

The results of the experiment are presented in the table below:

Table 1

x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
-1,04	-1,06	1,06	-0,53	-1,58	0,01	0,41	-0,79	-,018	-0,52
x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}	x_{20}
-1,60	-1,29	-0,10	1,27	0,01	0,60	2,25	-0,88	0,01	0,30
x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}	x_{27}	x_{28}	x_{29}	x_{30}
-0,08	0,54	1,02	1,68	1,12	-0,01	2,15	0,96	-0,80	-0,50
x_{31}	x_{32}	x_{33}	x_{34}	x_{35}	x_{36}	x_{37}	x_{38}	x_{39}	x_{40}
-2,33	-0,72	0,14	-0,98	0,74	-1,32	-1,46	0,35	0,32	0,35
x_{41}	x_{42}	x_{43}	x_{44}	x_{45}	x_{46}	x_{47}	x_{48}	x_{49}	x_{50}
-0,05	-0,27	0,65	3,47	2,19	0,40	0,52	-0,28	-1,57	1,92

(then each value in the table is multiplied by $10^4\ m/s$)

We write this selection variation series in the form of the following table.

Here $x_1^* = -2.33$ and $x_{50}^* = 3.47$ – peripherals of the $x_1^*, x_2^*, x_3^*, \dots, x_n^*$

Table 2

x_1^*	x_2^*	x_3^*	x_4^*	x_5^*	x_6^*	x_7^*	x_8^*	x_9^*	x_{10}^*
-2,33	-1,60	-1,58	-1,57	-1,46	-1,32	-1,29	-1,06	-1,04	-0,98
x_{11}^*	x_{12}^*	x_{13}^*	x_{14}^*	x_{15}^*	x_{16}^*	x_{17}^*	x_{18}^*	x_{19}^*	x_{20}^*
-0,90	-0,88	-0,80	-0,79	-0,72	-0,53	-0,52	-0,28	-0,27	-0,18
x_{21}^*	x_{22}^*	x_{23}^*	x_{24}^*	x_{25}^*	x_{26}^*	x_{27}^*	x_{28}^*	x_{29}^*	x_{30}^*
-0,10	-0,08	-0,05	-0,01	0,01	0,01	0,01	0,14	0,30	0,32

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x_{31}^*	x_{32}^*	x_{33}^*	x_{34}^*	x_{35}^*	x_{36}^*	x_{37}^*	x_{38}^*	x_{39}^*	x_{40}^*
0,35	0,35	0,40	0,41	0,52	0,54	0,60	0,65	0,74	0,96
x_{41}^*	x_{42}^*	x_{43}^*	x_{44}^*	x_{45}^*	x_{46}^*	x_{47}^*	x_{48}^*	x_{49}^*	x_{50}^*
1,02	1,06	1,12	1,27	1,68	1,92	2,15	2,19	2,25	3,47

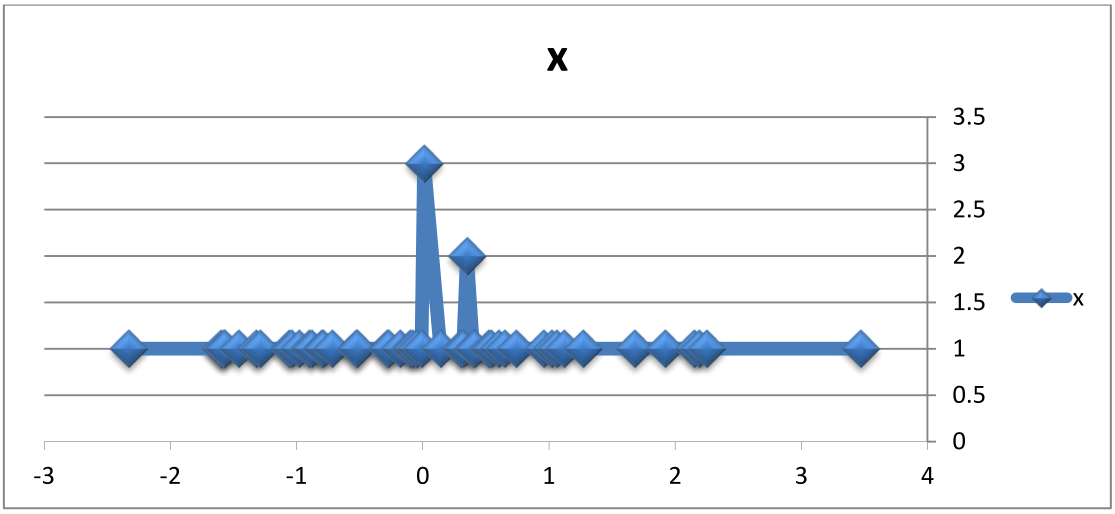
Using a series of variations, we construct the frequency distribution taking into account the iterations

z_i	z_1	z_2	z_3	z_4	z_5	z_6	z_7	z_8	z_9	z_{10}	z_{11}	z_{12}	z_{13}	z_{14}	z_{15}	z_{16}
n_i	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
z_{17}	z_{18}	z_{19}	z_{20}	z_{21}	z_{22}	z_{23}	z_{24}	z_{25}	z_{26}	z_{27}	z_{28}	z_{29}	z_{30}	z_{31}	z_{32}	z_{33}
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
z_{34}	z_{35}	z_{36}	z_{37}	z_{38}	z_{39}	z_{40}	z_{41}	z_{42}	z_{43}	z_{44}	z_{45}	z_{46}	z_{47}	z_{48}	z_{49}	z_{50}
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

$\sum n_i = n = 50$

We can calculate mathematical expectation value and dispersion value: θ_1^* and θ_2^* $\theta_1^* = \frac{\sum_{i=1}^{50} z_i n_i}{n} = 0.09324$ $\theta_2^* = \frac{\sum z_i^2 n_i}{n} = 1.337$

We draw the distribution polygon on the base 3-table



Based on the above data, it is possible to make a general hypothesis about the normality of the population.

Learning data using a nomogram

It is possible to estimate unknown parameters on the basis of a special template table called probability paper.

Here is the content of this method. Assume that $x_1, x_2, x_3, \dots, x_n$ are selected from the general set that belongs to the two-parameter family $F(x;\theta_1;\theta_2)$. Suppose, in a simpler way, that $F(x;\theta_1^*;\theta_2^*) \epsilon \{F(x;\theta_1;\theta_2)\}$ is constructed close enough to the empirical distribution function. Then θ_1^* *and* θ_2^* are the unknown parameters we are looking for.

In practice, the implementation of the "Nomagram method" is as follows. First x_1, x_2, x_3, … , x_n are reduced to a series of variations: x_1^*, x_2^*, x_3^*, … , x_n^*, then $(x; F^*(x))$ in the coordinate plane $A_i\left(x_i^*; \frac{2i-1}{2n}\right)$ $(i = 1,2,3,..,n)$ points are found. Then draw a straight line that is close to all A_i points. This straight line determines the values of θ_1^* va θ_2^*, which are the values of $\theta_1 va$ θ_2.

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For example, using the above, we determine the values of unknown parameters. From Table 2 and finding the points $A_i (i = 1,2,3, \dots, n)$ we come to the following table:

Table 4

A_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
$x_i = X_i^*$	-2.33	-1,60	-1,58	-1,57	-1,46	-1,32	-1,29	-1,06	-1,04	-0,98
$y_i = \frac{2i-1}{2n}$	0.01	0.03	0.05	0.07	0.09	0.11	0.13	0.15	0.17	0.19
A_i	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}
$x_i = X_i^*$	-0,90	-0,88	-0,80	-0,79	-0,72	-0,53	-0,52	-0,28	-0,27	-0,18
$y_i = \frac{2i-1}{2n}$	0.21	0.23	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.39
A_i	A_{21}	A_{22}	A_{23}	A_{24}	A_{25}	A_{26}	A_{27}	A_{28}	A_{29}	A_{30}
$x_i = X_i^*$	-0,10	-0,08	-0,05	-0,01	0,01	0,01	0,01	0,14	0,30	0,32
$y_i = \frac{2i-1}{2n}$	0.41	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.57	0.59
A_i	A_{31}	A_{32}	A_{33}	A_{34}	A_{35}	A_{36}	A_{37}	A_{38}	A_{39}	A_{40}
$x_i = X_i^*$	0,35	0,35	0,40	0,41	0,52	0,54	0,60	0,65	0,74	0,96
$y_i = \frac{2i-1}{2n}$	0.61	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.79
A_i	A_{41}	A_{42}	A_{43}	A_{44}	A_{45}	A_{46}	A_{47}	A_{48}	A_{49}	A_{50}
$x_i = X_i^*$	1,02	1,06	1,12	1,27	1,68	1,92	2,15	2,19	2,25	3,47
$y_i = \frac{2i-1}{2n}$	0.81	0.83	0.85	0.87	0.89	0.91	0.93	0.95	0.97	0.99

Delaying the test, we assume that the projection of the velocity of the hydrogen molecule is normally distributed and determine its parameters using a nomogram. In the probability paper (nomogram) we identify the points A_i and mark them with points. Let's draw a straight line $= kx + \alpha$:

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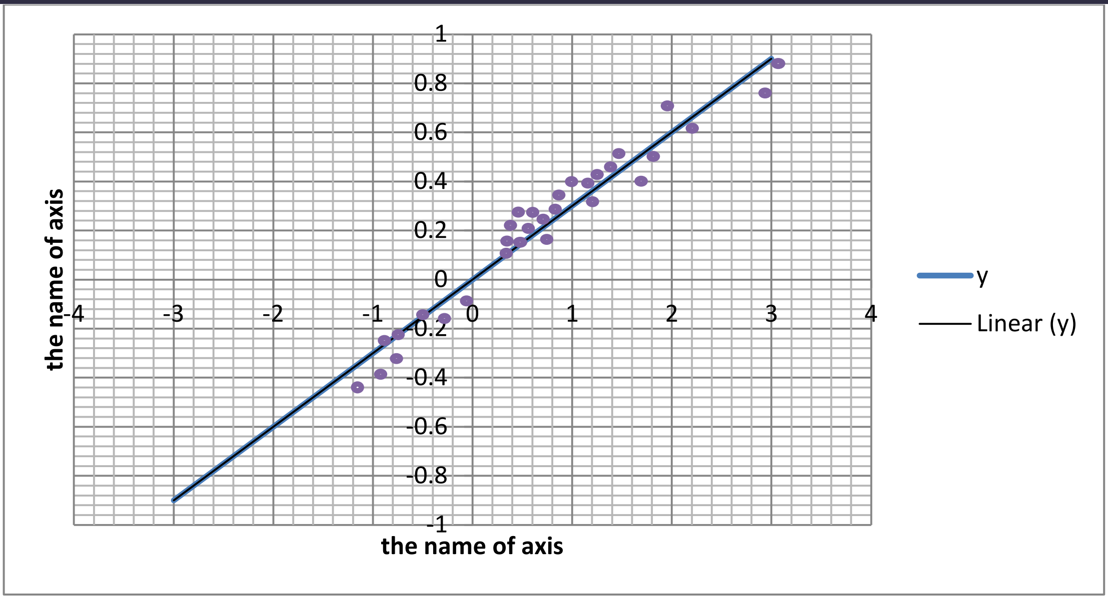

The value of θ_1^* mathematical expectation θ_1 is at the point of intersection of the straight line with the abscissa axis, i.e. $\theta_1^* = 0.06 = \alpha$, we determine k to determine the value θ_2 of variance θ_2^* : $k = 0.90$. Then $\theta_2^* = \frac{1}{k^2} = 1.23$. For comparison, recall the values found using Table 3.

The signs of Compliance

a)Verification of the normal distribution of the projection of the velocity of the hydrogen molecule using the Kolmagorov sign.

Using the Kolmagorov sign, we test the following general hypothesis:

H_0: The main set is normally distributed.

We perform the check for the value level $= 0.05$, the parameters of the normal distribution are not given, so we evaluate them. We choose θ_1^* and θ_2^* for the unknown parameters θ_1 and θ_2 so that they achieve the minimum variance of Kolmagorov's statistics.

Here is the Kolmagorov sign:

$$\rho = \sqrt{n}\left[\max_{1\le i\le n}\left|\Phi(x_i^*, \theta_1, \theta_2) - \frac{2i-1}{2n}\right| + \frac{1}{2n}\right]$$

Here $X_1^*, X_2^*, X_3^*, \dots, X_n^*$ $X_1, X_2, X_3, \dots, X_n$ selection variational series, $\Phi(x, m, \sigma^2) = \Phi\left(\frac{x-m}{\sigma^2}\right) - N(m; \sigma^2)$ - is the normal distribution. As the values of θ_1^* and θ_2^* we obtain the following values formed by the method of maximum similarity:

$\theta_1^* = m^* = 0.082$ and $\theta_2^* = \sigma^2 = 1.34$.

Now using the Kolmogorov sign. We will check the next hypothesis:

$$H_0: F(x) = \Phi(x_1, \theta_1^*, \theta_2^*) = \Phi(x; 0.082; 1.34)$$

First of all, we will calculate:

$$Y_i^* = \frac{x_i^* - \theta_1^*}{\sqrt{\theta_2^*}}$$

using the equation

$$\Phi(x_2^*, \theta_1^*, \theta_2^*) = \Phi\left(\frac{x_i^* - \theta_1^*}{\sqrt{\theta_2^*}}\right)$$

we find $\Phi(Y_i^*)$ in series from the table. $F_i^* = \frac{2i-1}{2i}$ va $S_i = |\Phi(Y_i^*) - F_i^*| \le 0.06$.

Then we find the value of ρ: $\rho_{kuzat} = 0.07\sqrt{50} \approx 0.49$.

We compare these quantities with 0.95 quantile. From the table $k_{0.95} = 1.36$ and

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$\rho_{kuzat} < k_{0.95}$. So we assume that the population is normally distributed.

b) Check the normality og the main set the symbol $\mathcal{X}^2$(xi – squared)

H_0: Let's re-examine the null hypothesis that the population is normally distributed. To do this, we divide the whole straight line into 8 intervals:

$(-\infty;-3), (-3;-2), (-2;-1), (-1;0), (0;1), (1;2)$ .. Since only one value falls on the first two intervals, we combine it with the third interval. Similarly, we combine the seventh and eighth intervals with the sixth interval. The result is four intervals. This statistical distribution by frequencies is given in Table 5 below.

Table 5

Interval	$(-\infty;1)$	$(-1;0)$	$(0;1)$	$(1;\infty)$
P_l	0.175	0.297	0.314	0.214
v_l	9	15	16	10
nP_l	8.7	14.8	15.7	10.7
$(v_l - nP_l)^2$	0.09	0.04	0.09	0.49
$\frac{(v_l - nP_l)^2}{nP_l}$	0.001	0.003	0.006	0.046

Using $\theta_1^* = 0.082$ and $\theta_2^* = 1.34$ we determine the probabilities that the hypothetical probabilities $P_i = P\big(X\epsilon(a,b)\big)$ $i = 1,2,3,\ldots - X$ fall into a given interval as follows:

$P_1 = \Phi(-1;\theta_1^*;\theta_2^*) = \Phi\left(\frac{-1-\theta_1^*}{\sqrt{\theta_2^*}}\right) = \Phi\left(\frac{-1-0.082}{\sqrt{1.34}}\right) = \Phi(-0.935) = 0.175$

$P_2 = \Phi(0;\theta_1^*;\theta_2^*) - \Phi(-1;\theta_1^*;\theta_2^*) = \Phi(-0.071) - \Phi(-0.935) = 0.297$

$P_3 = \Phi(1;\theta_1^*;\theta_2^*) - \Phi(0;\theta_1^*;\theta_2^*) = \Phi(0.795) - \Phi(-0.071) = 0.314$

$P_4 = 1 - \Phi(1;\theta_1^*;\theta_2^*) = 1 - \Phi(0.793)$
$= 1 - 0.786 = 0.214$

Then we calculate $\mathcal{X}_{obs}^2$:

$$\mathcal{X}_{obs}^2 = \sum_{i=1}^{L} \frac{(n_i - n_i p_i)^2}{n_i p_i} = 0.001 + 0.003 + 0.006 + 0.046 = 0.056$$

The degree of freedom of $\mathcal{X}^2$ is enqual to 1. $k_{0.95} = 3.841$ (from the table). So

$$\mathcal{X}_{obs}^2 < k_{0.95}$$

This means that the main set is normally distributed.

v) check using the sign ω^2

We now test the H_0 hypothesis that the projection of the velocity of a hydrogen molecule is normally distributed using the ω^2 sign.

The statistic ω^2 of the sign $\omega^2$is given by the following statistic:

$$\omega^2 = \omega^2(X_1, X_2, \ldots, X_n) = n \int_{-\infty}^{\infty} [F^*(x) - F_0(x)] p_0(x) dx.$$

Here $p_0(x) = F_0'(x)$ is exists and W_k is the critical area $(X_1, X_2, \ldots, X_n); \omega^2 > C$; C- is the critical point of the criterion. Using the variation series$X_1^*, X_2^*, \ldots, X_n^*$, ω^2 statistics can be conveniently written for practical calculations:

$$\omega^2 = \sum_{i=1}^{n} \left[F_0(X_i^*) - \frac{2i-1}{2n}\right] + \frac{1}{12n}$$

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The rule for testing the H_0 hypothesis using the symbol ω^2 is as follows. First, $X_1, X_2, \dots, X_n$ determine the variation series $X_1^*, X_2^*, \dots, X_n^*$ on the basis of the sample, then find $F_0(X_i^*)$ and calculate the observed value of ω^2. This value is compared to the critical point C. This given value level is found in Table C with α. H_0 or H_1 are accepted accordingly.

Now let's test the H_0 hypothesis. The stage of calculating the observed value of ω^2overlaps with the observed value of the Kolmagorov sign. Therefore, we perform calculations on the basis of Table 5.

$$\omega^2 = \sum_{i=1}^{n} S_i^2 + \frac{1}{12n}$$
$$= 0.01^2 + 0.04^2 + \cdots + 0.01^2 + \frac{1}{600} = 0.05$$

From $\alpha = 0.05$ we find the critical point in the table $C = 0.46$

$$\omega^2 < C, (0.05 < 0.46)$$

Thus, the sogn ω^2 also confirms the hypothesis H_0.

g) Check for normalcy using other symptoms.

Complex H_0: “Theoretical distribution $F(x)$ is normally distributed (ie $X_1, X_2, \dots, X_n$ is taken from the sample $N(m, \sigma^2)$. H_1: “Theoretical distribution distribution $F(x)$ is normally distributed ”verification is required. Of course, Kolmagorov, $\mathcal{X}^2$ (xi - squared), ω^2 (omega squared), mentioned in the previous paragraphs, are used to substantiate these assertions, and we have seen this in one example. In practice, it is easier to test for normalcy with symptoms that are less severe than they are. In this case, the empirical and theoretical moments of the selection are compared. In this case, the values of normal distribution parameters m and σ^2 are used, which are:

$$m^* = \sum_{i=1}^{n} \frac{X_i}{n} - \textit{selection average value}$$

$$S^{2*} = \frac{\sum_{i=1}^{n}(X_i - m)^2}{n-1} - \textit{corrected sample variance}$$

The first-order selection, the absolute central moment, is used as a sign of conformity. So let's look at the following statistics:

$$\mu^* = \frac{1}{n\sqrt{S^{2*}}} \sum_{i=1}^{n} |X_i - m^*|$$

The distribution of these statistics is conditional on the assumption that the hypothesis H_0 is valid, only that the sample size depends on , not on m and σ^2 . According to the law of large numbers, at $\mu^*\ at\ n \to \infty\ \mu$ (the first-order moment of the nominal distribution) approximates the probability $\mu \approx 0.8$. Naturally, if the value of the statistic μ^* differs sharply from , then the hypothesis H_0 is rejected. If $C_1 < \mu^* < C_2$, the hypothesis H_0 is accepted. When the value level α is symmetric, $C_1 = \mu_{\frac{\alpha}{2}}\ and\ C_2 = \mu_{1-\frac{\alpha}{2}}$ are obtained, where $\mu_\alpha - \mu^*$consists of the quantum α of the statics. This statistic is corrected by an n -dimensional sample, where the H_0 hypothesis is valid. The next characteristic to be used in the normalization test is based on the selective asymmetry coefficient, which is as follows.

$$\alpha^* = \frac{1}{n(S^{2*})^{\frac{3}{2}}} \sum_{i=1}^{n} (X_i - m^*)^3.$$

When the hypothesis H_0 is valid, the distribution of α^* depends only on n and not on m and σ^2. Its distribution is symmetric about zero. Comparing α^* with O and taking into account the above, we come

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to the following rule: If $-C < \alpha^* < C$, then at the value level α $C = a_{1-\frac{\alpha}{2}}, a_\alpha - \alpha^*$, the α quantile of the statistica with n-volume sample under this condition is derived from the normal population.

Another symptom used to check for normalcy is selective excision, which is as follows

$$\gamma^* = \frac{1}{n(S^{2*})^2}\sum_{i=1}^{n}(X_i - m^*)^4.$$

It is known that for a normal distribution, the excess is equal to 3, and it is defined as follows:

$$\gamma = \frac{M\big(X - M(X)\big)^4}{(DX)^2}$$

If $\gamma_{\frac{\alpha}{2}} < \gamma^* < \gamma_{1-\frac{\alpha}{2}}$, the H_0 hypothesis is accepted, where $\gamma_\alpha - \gamma^*$ is α quantile of the statistica.

In the last paragraph, the conformity check of the normalization check is based on the margins of the variation series. This characteristic is based on the fact that the density function of the normal distribution, x̄, tends to zero rapidly away from the mean. Therefore, a sample with very small and very large sample values cannot belong to a normal population. Therefore, the criterion is structured as follows:

$$x^* = \frac{1}{\sqrt{S^{2*}}}\max_{1\le i\le n}|X_i - m^*|$$

It will be $x^* < x_{1-\alpha}$ at the value level , where $x_\alpha -$ is α quantile of the statistica x^*, if the hypothesis H_0 is accepted, then the selection must be normal.

Example. Let us also consider the hypothesis H_0 with the projection of the velocity of the hydrogen molecule X. Let $= 0.02$. Based on Table 1 in 2.1, we calculate m^* and σ^{2*} :

$$m^* = \frac{1}{50}(-1.04 - 1.06 + 1.06 - \cdots - 1.57 + 1.92) = 0.082$$

$$\sigma^{2*} = \frac{1}{50}[(-1.04 - 0.082)^2 + (-1.06 - 0.082)^2 + \cdots + (1.92 - 0.082)^2] = 1.34$$

$$S^{2*} = \frac{50}{49}\sigma^{2*} = 1.37$$

Now, based on the tables, we calculate the observed values of the above statistics:

$$\mu^* = \frac{1}{n\sqrt{S^{2*}}}\sum_{i=1}^{n}|X_i - m^*| = \frac{1}{50\cdot\sqrt{1.37}}\sum_{i=1}^{50}|X_i - 1.34| = 0.79$$

$$\alpha^* = \frac{1}{n(S^{2*})^{\frac{3}{2}}}\sum_{i=1}^{n}(X_i - m^*)^3 = \frac{1}{50\cdot 1.60}\sum_{i=1}^{50}(X_i - 0.082)^3 = 0.57$$

$$\gamma^* = \frac{1}{n(S^{2*})^2}\sum_{i=1}^{n}(X_i - m^*)^4 = \frac{1}{50\cdot 1.60}\sum_{i=1}^{50}(X_i - 0.082)^4 = 0.57$$

$$x^* = \frac{1}{\sqrt{S^{2*}}}\max_{1\le i\le n}|X_i - m^*| = \frac{1}{\sqrt{1.37}}\max_{1\le i\le 50}|X_i - 0.082| = 2.90$$

We now identify the critical points from the table.

$$\mu_{0.01} = 0.7291, \mu_{0.99} = 0.8648, \alpha_{0.99} = 0.787$$

Bunda $\mu_{0.01}$ va $\mu_{0.99}$ $n = 51$ hajmli tanlama uchun ($n = 50$ ga yaqin) olingan $\gamma_{0.01} = 1.95$, $\gamma_{0.99} = 4.92$, $x_{0.98} = 3.370$

kuzatilgan kritik nuqtalarni taqqoslash bilan H_o gipoteza to‘g‘ri degan xulosaga kelamiz.

Thus, we examined the normality of the general set related to the projection of the velocity of the hydrogen molecule in 7 different ways, and in all cases came to the conclusion that the hypothesis H_o is correct.

Any practitioner will follow the adage, "Seven measures, one cut." In addition to the above, we used Shappard's corrections to differentiate between theoretical moments and empirical moments. Based on it, we can take μ^* , α^* , γ^* and x^* as symptoms. The development of such symptoms is both practical and theoretical.

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