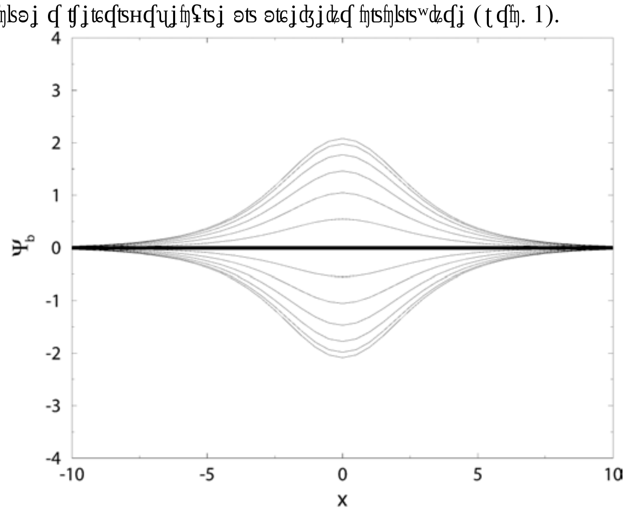
[illegible]

[illegible]

1. [illegible]

[illegible] sine-[illegible] ([illegible]), φ^4 [illegible] ([illegible]. 1).



[illegible].1 [illegible]

[illegible] [1]).

[illegible] l [illegible] X_l [illegible] P_l, [illegible] t. [illegible] H [illegible]

$dX_l / dt = \partial H / \partial P_l$ $dP_l / dt = -\partial H / \partial X_l$.

$H = 0$ $X_l = P_l = 0$.

$H = 0$, Ω_q

Ω_q

q.

$|\Omega_q| \le \Omega_{\max}$.

Ω_q

$|\Omega_q| \ge \Omega_{\min}$).

Ω_q^i

$$X_l(t) = X_l(t + T_b) + \lambda m_l\,,\;\; P_l(t) = P_l(t + T_b)\,, \qquad (1)$$

$$X_{l \to \infty} \to 0\,,\; P_{l \to \infty} \to 0\,,$$

T_b - m_l – λ X_l λ).

$\lambda = 0$. $\lambda \ne 0$ $m_l \ne 0$ [1,2,3].

$X_l(t) = \sum_k A_{kl}\, e^{ik\omega_b t} + \lambda m_l \frac{t}{T_b}$ $\quad (\omega_b = 2\pi / T_b)$.

$A_{k, l \to \infty} \to 0$

$m_{|l|>|l_0|} = 0$. [illegible] k [illegible] A_{kl} [illegible] l). [illegible] $k\omega_b$ [illegible]

[illegible] $k\omega_b = \Omega_q$, [illegible]

$$k\omega_b \neq \Omega_q \qquad (2)$$

[illegible] [4]. [illegible] ($k = 0$) [illegible] $\Omega_{q=0} = 0$. [illegible]

[illegible] (2) - [illegible] [1,5].

[illegible] [1].

[illegible] (2), [illegible] $k_1\omega_1 + k_2\omega_2 \neq \Omega_q$ [illegible] ω_1, ω_2 [illegible] (k_1, k_2). [illegible] [4].

[illegible] [6] [illegible] [7].

[illegible] $PtCl$ [8], [illegible] [9], [illegible] [10], [illegible].

[illegible] [11].

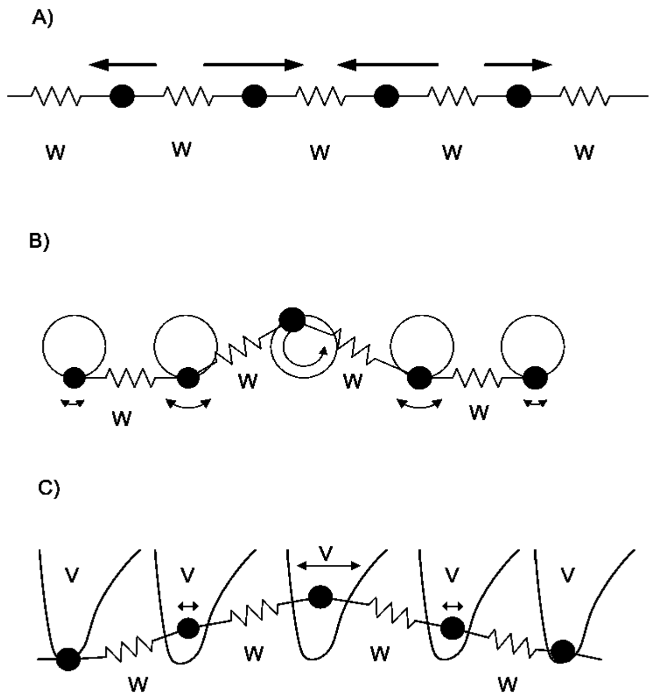
2. [illegible]

[illegible]

$$H = \sum_l \left\{ \frac{1}{2} P_l^2 + V(X_l) + \sum_{l' \neq l} W_{l-l'}(X_l - X_{l'}) \right\}, \qquad (3)$$

[illegible] $V(z)$, $W_l(z)$ [illegible] $V(0) = W_l(0) = 0$.

[illegible] $\partial^2 V / \partial^2 z$ [illegible] $z = 0$, [illegible] Ω_q, [illegible]. [illegible] .2 [illegible].



ţ ɖɦ.2

ʉ⍽ȷʤʘʪɖɥȷɧʢʦȷ ʨʘɧʧʨȷɴȷʥȷʥɖȷ ʘʤʧʥɖʪʑɴ ʙʨɖʟȷʨʦɘ ɴʥʷ ʢʦʥʢʨȷʪʥ ʳ ⍽

ʧʦʪȷʥɥɖʘʥʦɘ (3) : a) $V(z) \equiv 0$, $W(z) = \frac{1}{2} z^2 + \frac{1}{4} z^4$,

b) $V(z) \equiv 0$, $W(z) = 1 - \cos(z)$,

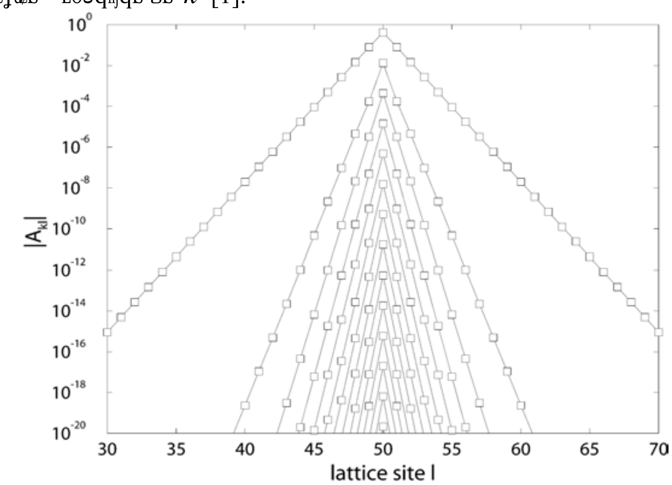
c) $V(z) = \frac{1}{2}z^2 + \frac{1}{4}z^4$, $V(z) = \frac{1}{2}z^2$.

[illegible] W [illegible].

[illegible] $W_{l>l_c} = 0$ [illegible] ([illegible]) [illegible] W_l [illegible] l, [illegible] Ω_q^2 [illegible] q. [illegible], [illegible] [illegible]-[illegible] A_{kl}. [illegible]

$$A_{kl} \propto \int_{\Xi} \frac{\cos(ql)}{(k\omega_b)^2 - \Omega_q^2} \mathrm{d}^d q \, , \qquad (4)$$

[illegible] Ξ. [illegible] A_{kl} [illegible] l ([illegible]. 3), [illegible] k [1].

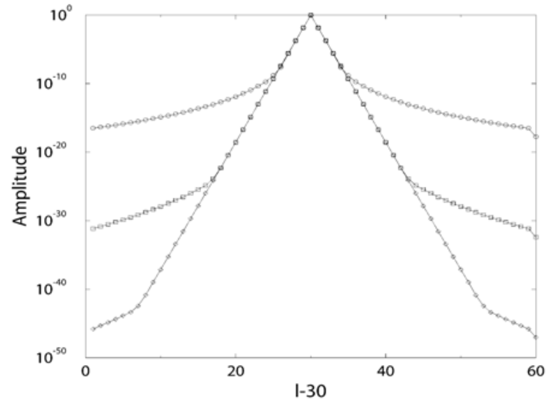


[illegible]. 3 [illegible] A_{kl} [illegible] l. [illegible] k [illegible] ([illegible]. [1]).

[illegible] A_{kl} (4) [illegible], [illegible] $k\omega_b$ [illegible] Ω_q. [illegible], [illegible] A_{kl}, [illegible] tsls ɥʝʥlstɞθ ʙtɞɕʟʝtɞθ, ʥʝɱʧtɞθɘʝнʥɕɘθ нʥʷ ʢtsʥʝɥʥtsʛts ɥɕɱʥθ $k' \neq k$ ɕ ʥʝʥɕʥʝʡʥʳʝ ʧtsʧtɞθɘʢɕ нtsʥʞʥʳ ʙʳlsʴ ʨɥlsʝʥʳ, ɥlsts ʧtɞɕɘtsнɕls ʢ ɕʟʤʝʥʝʥɕʶ ɱtstslsɘʝlsɱlsɘʨʶʰɕʭ ʧtsʢθʟθlsʝʥʝʡ [12].

2.1 ɸʥʛʝʙtɞθɕɥʝɱʢɕ ɱʧθнθʶʰʝʝ ɘʟθɕʤtsнʝʡɱlsɘɕʝ

ʈθɱɱʤtslstɞɕʤ tsнʥtsʤʝtɞʥʨʶ tɞʝʰʝlsʢʨ ɱ θʥʛʝʙtɞθɕɥʝɱʢɕ ɱʧθнθʶʰɕʤ ɘʟθɕʤtsнʝʡɱlsɘɕʝʤ $W_l(z) \propto 1/l^s$ ɕ $\partial^2 V / \partial^2 z|_{z=0} \neq 0$. ʊθʢ ʢθʢ Ω_q^2 ʨʞʝ ʥʝ ʙʨнʝls θʥθʥɕlsɕɥʥθ ʧts q, ɘʳtɞθʞʝʥɕʝ (4) ʧtsнtɞθʟʨʤʝɘθʝls, ɥlsts ʥθ ʙtsʥʴʰɕʭ tɞθɱɱlstsʷʥɕʷʭ ʧtɞtsɱlstɞθʥɱlsɘʝʥʥtsʝ ɱʧθнθʥɕʝ ʌʨtɞʴʝ-ʢtsʵʬʬɕɥɕʝʥlstsɘ ʙʨнʝls lsθʢʞʝ θʥʛʝʙtɞθɕɥʝɱʢɕʤ $A_{kl} \propto 1/l^s$. ʃнʥθʢts ʧtɞɕ $s \to \infty$ ɘʟθɕʤtsнʝʡɱlsɘɕʝ ɱlsθʥtsɘɕlsɱʷ ʢtstɞtslsʢtsнʝʡɱlsɘʨʶʰɕʤ (ɘʟθɕʤtsнʝʡɱlsɘɕʝ ʙʥɕʞθʡʰɕʭ ɱtsɱʝнʝʡ). ʈʥʷ ʧtsʥɕʤθʥɕʷ ʧʝtɞʝʭtsнθ ʢ ʵʢɱʧtsʥʝʥɥɕθʥʴʥtsʤʨ ɱʧθнʨ ɘ ʵlstsʤ ʧtɞɕнʝʥʝ tɞθɱɱʤtslstɞɕʤ ɱʥʨɥθʝ, ʢtsʛнθ $k\omega_b$ ʙʥɕʟʢts ʢ ʛtɞθʥɕɥʝ ʟtsʥʳ Ω_q, ʢtslststɞθʷ ʭθtɞθʢlsʝtɞɕʟʨʝlsɱʷ ʥʝʢtslststɞʳʤ ɘtsʥʥtsɘʳʤ ɘʝʢlststɞtsʤ q_c. ʊθʢ ʢθʢ ʧtsнɕʥlsʝʛtɞθʥʴʥθʷ ʬʨʥʢɥɕʷ (4) tɞθɱʭtsнɕlsɱʷ ɘʙʥɕʟɕ q_c, ʤʳ ʤtsʞʝʤ ɕɱʧtsʥʴʟtsɘθlsʴ ʧtɞɕʙʥɕʞʝʥɕʝ ɱlsθɥɕtsʥθtɞtsʡ ʬθʟʳ ɕ tɞθʟʥtsʞɕlsʴ Ω_q^2 tsʢtsʥts q_c, ʨɥɕlsʳɘθʷ lstsʥʴʢts ʧʝtɞʳʡ ʧtstɞʷнtsʢ tɞθʟʥtsʞʝʥɕʷ. ʈʥʷ ɱʥʨɥθʷ $s > 3$ ɘʝнʨʰɕʡ ʧtstɞʷнtsʢ ʟθɘɕɱɕʤtsɱlsɕ Ω_q^2 tsls q ʙʨнʝls ʧtɞtsʧtstɞɥɕtsʥθʝʥ $(q - q_c)^2$. ʅʝθʥɕʟθɥɕʷ ɱʢtɞʳlsθ ɘ ɥʥʝʥθʭ ɘʳɱʰʝʛts ʧtstɞʷнʢθ ʧts $(q - q_c)$ ɕ ʥʝ ʧtɞtsʷɘʥʷʝlsɱʷ ɘ ʵlstsʤ ʧtɞɕʙʥɕʞʝʥɕɕ. ɪ ʵlstsʤ ɱʥʨɥθʝ ʤʳ ʧtsʥʨɥθʝʤ ʵʢɱʧtsʥʝʥɥɕθʥʴʥtsʝ ɱʧθнθʥɕʝ A_{kl} ɘ ʧtɞtsɱlstɞθʥɱlsɘʝ. ʃнʥθʢts, ʤʳ ʟʥθʝʤ, ɥlsts θɱɕʤʧlsʴlsɕɥʝɱʢθʷ ʟθɘɕɱɕʤtsɱlsʴ A_{kl} ʧts l - θʥʛʝʙtɞθɕɥʝɱʢθʷ. ʊθʢɕʤ tsʙtɞθʟtsʤ, ʤʳ ʟθʢʥʶɥθʝʤ, ɥlsts нʥʷ ɥθɱlstsls ʙtɞɕʟʝtɞθ, ʙʥɕʟʢɕʭ ʢ ʛtɞθʥɕɥʝ ɱʧʝʢlstɞθ Ω_q, ʧtɞtsɱlstɞθʥɱlsɘʝʥʥθʷ ʥtsʢθʥɕʟθɥɕʷ ʙʨнʝls ʵʢɱʧtsʥʝʥɥɕθʥʴʥθ нts ʥʝʢtslststɞtsʛts ʭθtɞθʢlsʝtɞʥtsʛts tɞθɱɱlstsʷʥɕʷ l_c, ʥts ɱlsθʥtsɘɕlsɱʷ θʥʛʝʙtɞθɕɥʝɱʢtsʡ ʥθ ʙtsʥʴʰɕʭ tɞθɱɱlstsʷʥɕʷʭ [13].



[illegible]. 4 [illegible] $s = 10, 20, 30$. [illegible] [13].

[illegible]

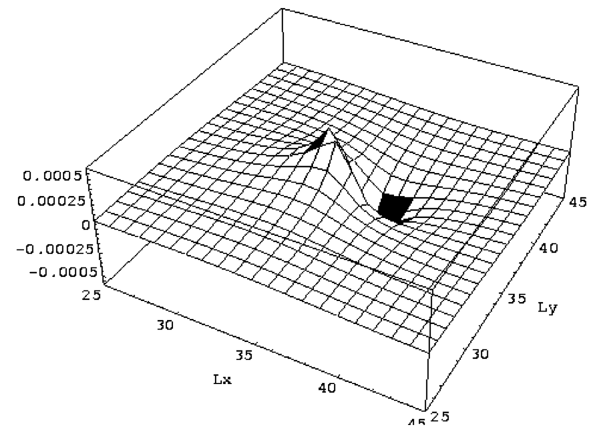
$$\frac{\ln l_c}{l_c} \approx \frac{\nu}{s}, \qquad (5)$$

[illegible] ν – [illegible] (5) [illegible] $l_c \to \infty$ [illegible] $s \to \infty$, [illegible] $\nu \to 0$ ([illegible] $k\omega_b \to \Omega_{q_c}$) [illegible] $l_c \to \infty$. [illegible] Ω_q, [illegible] [13].

2.2 [illegible]

[illegible] Ω_q [illegible] $\Omega_{q=0} = 0$, [illegible] $H = 0$ [illegible] $k = 0$ [illegible] $(k \neq 0)$ [illegible] $X_l \to -X_l$, [illegible] ʧtɕjtsʙtɕΘʟtsɘΘʥʠjʤ ʠ $A_{kl} \equiv 0$ ʜʥʷ ʮjlsʥʳ꜒ k, ɘʢʥʴʮΘʷ $k = 0$. ʆʜʥΘʢts jʩʥʠ ʜΘʥʥΘʷ ʩʠʤʤjlstɕʠʷ ʥΘtɕʑʰjʥΘ, ɘʩj ʌʑtɕʲj ʢtsꜗʬʬʠʮʠjʥlsʳ ʙʑʜʑls ʥjʥʑʥjɘʳj, ɘʢʥʴʮΘʷ $k = 0$.

ɿtɕjʜʧtsʥtsʯʠʤ, ʮlsts Ω_q^2 ΘʥΘʥʠlsʠʮʥΘ ʧts q. ʊΘʢ ʢΘʢ ʥʑʥjɘΘʷ ʛΘtɕʤtsʥʠʢΘ $k = 0$ ʥj ʤtsʯjls ʩʧΘʜΘlsʲ ꜗʢʩʧtsʥjʥʮʠΘʥʲʥts ʥΘ ʙtsʥʲʰʠ꜒ tɕΘʩʩlstsʷʥʠʷ꜒ tsls ʮjʥlstɕΘ ʙtɕʠʟjtɕΘ, tsʩʥtsɘʥΘʷ ʮΘʩlsʲ tɕjʰjʥʠʷ ʥΘ ʙtsʥʲʰʠ꜒ tɕΘʩʩlstsʷʥʠʷ꜒ ʙʑʜjls ʧtɕjʜʩlsΘɘʥjʥΘ ʥʑʥjɘtsʔ ʛΘtɕʤtsʥʠʢtsʔ, ʤjʜʥjʥʥts ʑʙʳɘΘʴʰjʔ ʬʑʥʢʮʠjʔ, ʷɘʥʷʴʰjʔʩʷ ʩlsΘlsʠʮjʩʢtsʔ ʜjʬtstɕʤΘʮʠjʔ tɕjʰjlsʢʠ. ʉtstslsɘjlsʩlsɘʑʴʰjj ʥʠʥjΘtɕʠʟtsɘΘʥʥtsj ʑtɕΘɘʥjʥʠj ʙʑʜjls ʧtsʜtsʙʥts ʑtɕΘɘʥjʥʠʴ ʜʥʷ ʥΘʧtɕʷʯjʥʠʷ ɘ ʤj꜒Θʥʠʢj ʜjʬtstɕʤʠtɕtsɘΘʥʥtsʛts lsɘjtɕʜtsʛts lsjʥΘ ʧtsʜ ʜjʔʩlsɘʠjʤ ʥtsʢΘʥʲʥtsʔ ʜjʬtstɕʤΘʮʠʠ (ʷʜtɕΘ ʙtɕʠʟjtɕΘ). ʅΘʧtɕʷʯjʥʠj ɘ ꜗlststʤ ʩʥʑʮΘj ʙʑʜjls ʩʧΘʜΘlsʲ ΘʥʛjʙtɕΘʠʮjʩʢʠ ɘ ʧtɕtsʩlstɕΘʥʩlsɘj. ʈjʟʥʲlsʠtɕʑʴʰʠʔ ΘʥʛjʙtɕΘʠʮjʩʢʠʔ ʩʧΘʜ $A_{0l} \propto 1/|l|^{d-1}$ ʙʳʥ ʧtsʜlsɘjtɕʯʜʸʥ ʮʠʩʥjʥʥts ʜʥʷ ʩʥʑʮΘʷ $d = 2$ [14] (ʈʠʩ. 5).



ʈʠʩ. 5 ʉlsΘlsʠʮjʩʢΘʷ ʜjʬtstɕʤΘʮʠʷ Θʢʑʩlsʠʮjʩʢtsʛts ʙtɕʠʟjtɕΘ [14].

3. ɿtstɕtsʛ ʧts ʑʥjtɕʛʠʠ

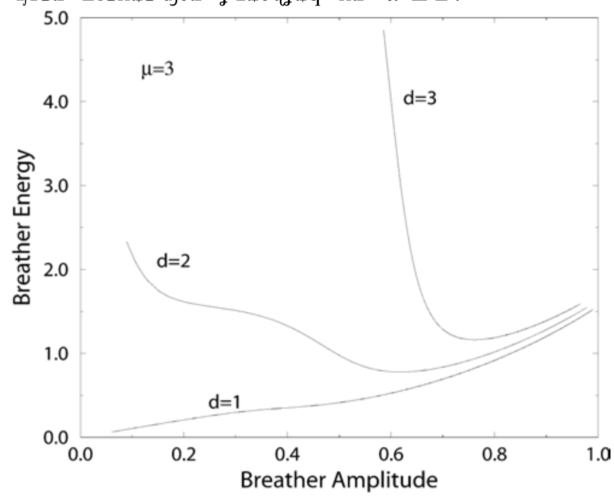
ɿtɕʷʤtsj ʩʥjʜʩlsɘʠj ʧtɕtsʩlstɕΘʥʩlsɘjʥʥtsʛts ʩʧΘʜΘ ʙtɕʠʟjtɕΘ - ꜗlsts ɘtsʟʤtsʯʥtsj ʥΘʥʠʮʠj ʥjʥʑʥjɘtsʛts ʧtstɕtsʛΘ ʧts ʑʥjtɕʛʠʠ. ʅΘʧtsʤʥʠʤ, ʮlsts ʙtɕʠʟjtɕ ʧtɕjʜʩlsΘɘʥʷjls ʩtsʙtsʔ tsʜʥtsʧΘʤjlstɕʠʮjʩʢtsj ʩjʤjʔʩlɘts ʧjtɕʠtsʜʠʮjʩʢʠ꜒ ɘts ɘtɕjʤjʥʠ lstɕΘjʢlststɕʠʔ ɘ ʬΘʟtsɘtsʤ ʧtɕtsʩlstɕΘʥʩlsɘj. ʅΘʥʠʮʠj ʠʥʠ tsʩʩʠʥʑʩʩʠj ʧtɕtsʛ ʧts ʑʥjtɕʛʠʠ ʷɘʥʷjlsʩʷ ʬʠʟʠʮjʩʢʠ ɘΘʯʥʳʤ. ʢʥjtɕʛʠʷ ʙtɕʠʟjtɕΘ ʤtsʯjls ʠʩʮjʟʥʑʲ lstsʥʲʢts ɘ ʧtɕjʜjʥj ʥʑʥjɘtsʔ Θʤʧʥʠlsʑʜʳ, ls.j. ʢtsʛʜΘ ω_b ʜtsʩlsʠʛΘjls ʛtɕΘʥʠʮ ʟtsʥʳ Ω_q. ʢʥjtɕʛʠʷ ʙtɕʠʟjtɕΘ E_b tsʮjʥʠɘΘjlsʩʷ ʢΘʢ

$$E_b \propto \int_1^{\infty} r^{d-1} F_d^2(\delta r)\,\mathrm{d}\,r\,, \qquad (6)$$

[illegible] $A_{1r}^2 \propto F_d^2(\delta r)$. [illegible] ([illegible] Ω_q^2), [illegible] $F_d(\delta r)$ [illegible] δ. [illegible] Ω_q [illegible] $(q-q_c)$, [illegible] $\delta \propto |\omega_b - \Omega_{q_c}|$. [illegible] A [illegible] ω_b, [illegible] $|\omega_b - \Omega_{q_c}| \propto A^2$. [illegible] [15]:

$$E_b \propto |\omega_b - \Omega_{q_c}|^{1-d/2}. \qquad (7)$$

[illegible] $d \ge 2$.



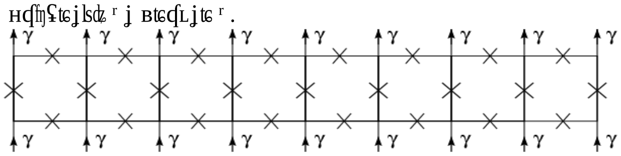
[illegible]. 6 [illegible] $d = 1,2,3$ [15].

[illegible] ([illegible]. 6). [illegible]

[illegible] [15]. [illegible] Ω_q^2 [illegible] [13].

4. [illegible]

[illegible]



[illegible].7 [illegible] $\times$, γ - [illegible].

[illegible]

[illegible] I_l, [illegible] $\varphi_l(t)$ [illegible]:

$$\ddot{\varphi}_l + \alpha\dot{\varphi}_l + \sin\varphi_l = I_l . \qquad (8)$$

[illegible] $t_0 = \sqrt{C\Phi_0/(2\pi I_c)}$, [illegible] Φ_0 – [illegible], C [illegible] I_c – [illegible], $\alpha = \sqrt{\Phi_0/(2\pi I_c C R_N^2)}$ - [illegible]. [illegible] φ_l^v, φ_l^h [illegible] $\tilde{\varphi}_l^h$ [illegible] l-[illegible] [16]

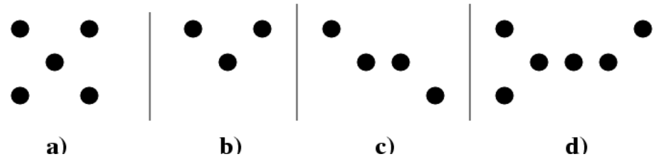
$$\begin{aligned} &\ddot{\varphi}_l^v + \alpha\dot{\varphi}_l^v + \sin\varphi_l^v = \gamma + (\varphi\,\varphi_l^v - \nabla\tilde{\varphi}_{l-1}^h + \nabla\varphi_{l-1}^h)/\beta_L \\ &\ddot{\varphi}_l^h + \alpha\dot{\varphi}_l^h + \sin\varphi_l^h = -(\varphi_l^h - \tilde{\varphi}_l^h + \nabla\varphi_l^v)/(\eta\beta_L) \qquad , \qquad (9) \\ &\ddot{\tilde{\varphi}} + \alpha\dot{\tilde{\varphi}}_l^h + \sin\tilde{\varphi}_l^h = (\varphi_l^h - \tilde{\varphi}_l^h + \nabla\varphi_l^v)/(\eta\beta_L) \end{aligned}$$

ǴНǰ γ – ǳǻǻǳǮǳǯǳǻǳǳ ʳ ʔ ǂǻǹǻǻʷǳǳ ʳ ʔ ǻǻʕ ǝ ǰНǯǳǯǳǮǭ I_{cV},

$\beta_L = 2\pi L I_{cV} / \Phi_0$ - ǂǭǻǳǰǻǻ НǯǹʕǻǰǻǳǻǹǻǮ, L - ǹǭǳǻǯǳНǲʕǳǯʷ

ˡǳǰǳǰǻǭǻǳǻʔ ʷǳǰʔʕǯ ǯ $\eta = I_{cH} / I_{cV}$ – ǂǭǻǭǳǰǻǻ ǭǳǯǻǻǻǻǂǯǯ, ǻǭǝǳ ʳ ʔ ǻǻǳǻ ʰ ǰǳǯ ʸ ǝǰǳǯǳǯǳ ʕǻǯǻǯǳǰǹʕǯǭ ǻǻʕǻǝ ǳǭ Ǵǻǻǯǻǳǻǭǳˡǳǻǳ ǯ ǝǰǻǻǯʕǭǳˡǳǻǳ ʕǻǳǻǭʕǻǭǭ. ǫǭǻǳǻǹǻǳ ʳ ǰ ǻǂǰǻǭǻǻǻ ʳ ǻǂǻǰНǰǳʷ ʸ ǻǹʷ ʕǭʕ $\nabla\varphi_l = \varphi_{l+1} - \varphi_l$, $\Phi\varphi_l = \varphi_{l+1} - 2\varphi_l + \varphi_{l-1}$.

ɹǻǯǻǰǻ (ǝ НǭǳǳǻǳǴ ǹǳǲǳǰǭǰ ǻǻǻǻǻвǻǯǻǰǻ) ǹǻǻǻǝǰǻǹǻǲǰǻ ǹǻǹǻǻʷǳǯ ʸ ʕǻǴНǭ ʕǻǳǰǳǻǰ ǳǯǹǳǻ ʕǻǳǻǭʕǻǻǝ ǳǭǭǻНǯǻǹʷ ǝ ǻǰǻǯǹǻǯǝǳǻǳǴ ǹǻǹǻǻʷǳǯǯ $m_l \neq 0$, ǻǻǴНǭ ʕǭʕ ǻǹǻǭǳˡǳ ʳ ǰ ʕǻǳǻǭʕǻ ʳ ǻǹǳǯǳǳǯǻǲ ʸ ǻ ǻʕǻǳǻ ǹǝǰǻǭǂǻǻǝǻНʷ ʰ ǰǴǻ ǹǻǹǻǻʷǳǯʷ $(m_l = 0)$. ʕʕǹǂǰǻǯǳǰǻǻǭǳˡǳǻ в ʳ ǳǯ ǻвǳǭǻǲЖǰǳ ʳ вǻǯǻǰǻ ʳ ǻǭǻǳǯǳǳ ʳ ǭ ǻǯǂǻǝ ǹ a) ǹǯǳǳǰǻǻǯǰʔ ǝǰǻǭ-ǝǳǯǻ, b) ǹǯǳǳǰǻǻǯǰʔ ǂǻǭǝǻ-ǳǰǝǻ, c) ǯǳǝǰǻǹǯǰʔ ǯ d) ǻǻǹǲǻǹǻǝǯǰǳǳ ǹǯǳǳǰǻǻǯǯ [17,18,19]. ʂǭЖНǭʷ ǴǻǲǂǂǭǳǳЖǰǻ ǹǻНǰǻЖǭǻˡ ǳ ʸ вǻǰ ǯǯǹǳǻ ǝǰǻǻǯʕǭǳˡǳ ʳ ǭ ǻǰǻǯǹǻǯǝǳ ʳ ǭ ʕǻǳǻǭʕǻǻǝ n_r.



ǫǯǹ. 8 ʂǳǭǹǹǯʷǯʕǭǯǯʷ вǻǯǻǰǻǻǝ ǂǻ ǹǯǳǳǰǻǻǯʷǳ ǝ ǹǯǹǻǰǰ ʕǻǳǻǭʕǻǻǝ ǳЖǻǰʷǹǻǳǭ. ɣǰǻǳ ʳ ǰ ʕǻǲЖǻǯʕǯ ǻвǻǻǳǭǯǭ ʸ ǻ ʕǻǳǻǭʕǻ ʳ, ǳǭǭǻНʷ ʰ ǯǰǹʷ ǝ ǻǰǻǯǹǻǯǝǳǻǳ ǹǻǹǻǻʷǳǯǯ. a) ǹǯǳǳǰǻǻǯʷ *ǝǰǻǭ-ǝǳǯǻ*, b) ǹǯǳǳǰǻǻǯʷ *ǂǻǭǝǻ-ǳǰǝǻ*, c) *ǯǳǝǰǻǹǯʷ* ǯ d) ǻǻǹǲǻǹǻǝǯǰǳǳ ǹǯǳǳǰǻǻǯǯ. ɣǯǹǳǻ ǝǰǻǻǯʕǭǳˡǳ ʳ ǭ ǻǰǻǯǹǻǯǝǳ ʳ ǭ ʕǻǳǻǭʕǻǻǝ ǳǻЖǰǻ в ʳ ǻˡ ǳ ʸ в ʳ ǳ $n_r \geq 1$.

ʉ ˡʕǹǂǰǻǯǳǰǻǻǭǳˡǳǻʔ ǻǻǯʕǯ ǻǻǰǳǯʷ ʕǭЖН ʳ ʔ вǻǯǻǰǻ ǭǻǭʕǻǰǻǯǻǲǰǻǹʷ ǹǝǻǰʔ ǝǻǳˡǻ-ǭǳǂǰǻǳǻʔ ǭǻǭʕǻǰǻǯǹǻǯʕǻʔ. ʉǻǰНǳǰǰ ǂǭНǰǳǯǰ ǳǭǂǻʷЖǰǳǯʷ ǯǰǻǰ ǝǰǻǯǻǭǳˡǳ ʳ ʔ ʕǻǳǻǭʕǻ ǻǭǝǳʷǰǻǹʷ $V = \frac{1}{T_b}\int_0^{T_b} \dot{\varphi}_l^v \, \mathrm{d}t$. ʀǻ ǻǭʕǻǳǻǝ ʂǯǻǭǴǻʷǭ ǹǳǰНǲǰǻ ǯǻǻ Нǳʷ вǻǯǻǰǻǻǝ ǻǯǂǭ a) ǯ d) $V = 2\omega_b$ ǯ Нǳʷ вǻǯǻǰǻǻǝ ǻǯǂǭ b) ǯ c) $V = \omega_b$.

ʋǹǻǰНǳǯǝ ǲǻǭǝǳǰǳǯǰ НǝǯЖǰǳǯʷ ǳǭ ǂǰǻǯǻН вǻǯǻǰǭ ǳǻЖǳǻ ǂǻǳǲǯǯǻˡ ǹǳǰНǲ ʸ ʰ ǯǰ ǂǻǯвǳǯЖʸǳǻ ʳ ǰ ǻǳǭǯǰǳǯʷ Нǳʷ ǯǭǹǻǻǻ ǻǭǻǳǯǯǳ ʳ ǭ ǻǯǂǻǝ вǻǯǻǰǻǻǝ [20].

$$\omega_b^a = \frac{n_r \gamma}{2\alpha(n_r + \eta)}, \quad \omega_b^{c,b} = \frac{n_r \gamma}{\alpha(n_r + 2\eta)}, \qquad (10)$$

$$\omega_b^d = \frac{n_r \gamma}{\alpha(2n_r + 3\eta)}.$$

[illegible]

[illegible]

[illegible]

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