Universitatea Transilvania din Brasov

TEZĂ DE ABILITARE

Contribuţii la dezvoltarea si aplicarea unor metode numerice în domeniul simulării propagării undelor si pulsurilor elastice in medii omogene si neomogene

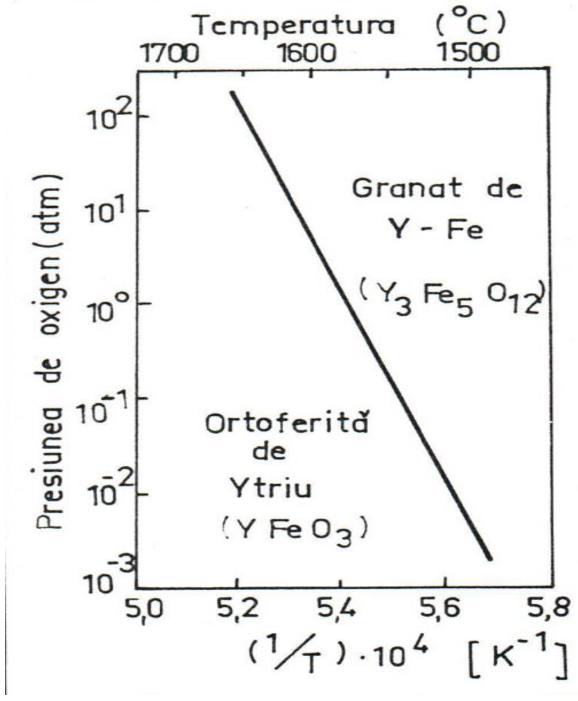
Domeniul: INGINERIA MATERIALELOR

Autor:Conf Dr. Fiz. CREŢU NICOLAE CONSTANTIN

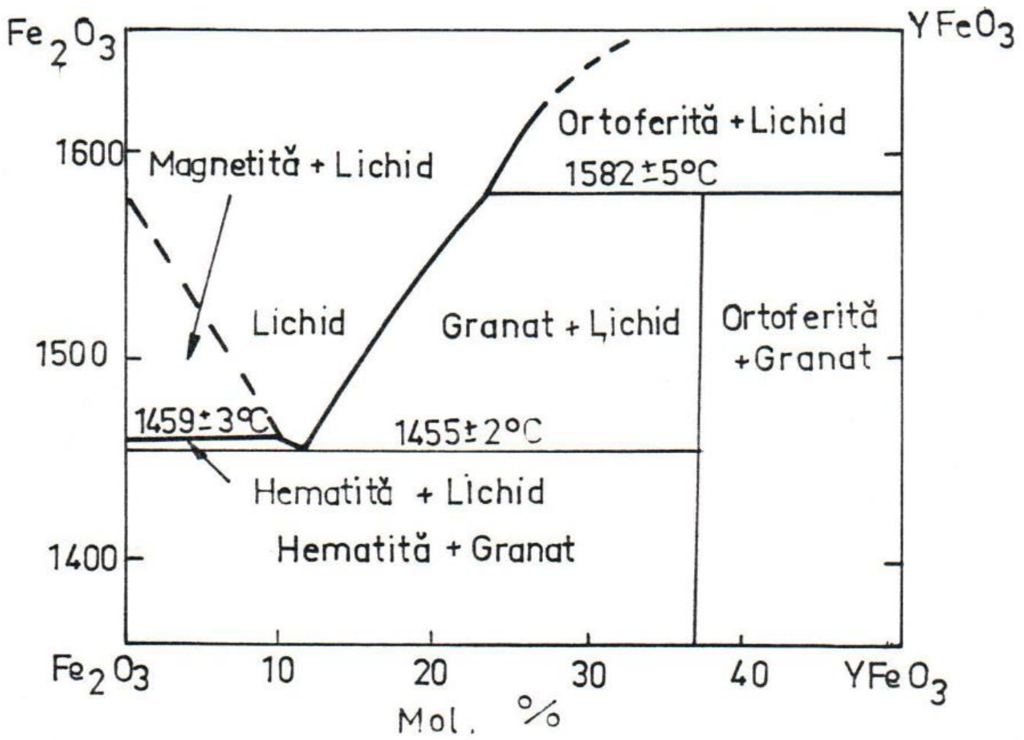
Obţinerea şi studiul granaţilor policristalini de Y , Dy

Presiunea de oxigen: 0.02-0.03 atm

$$\left(2000 - 3000 \frac{N}{m^2} \right)$$



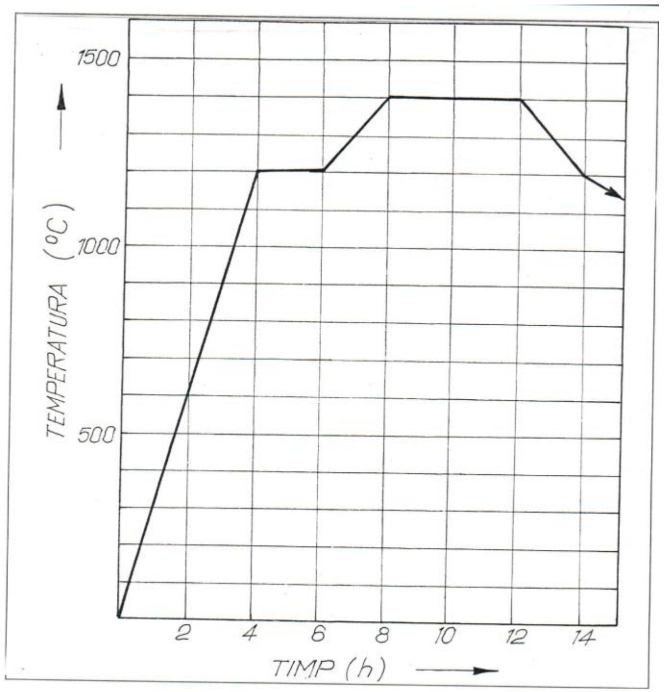
Sistemul Fe2O3-Y2O3 Temperatura de reactie in functie de presiunea de oxigen



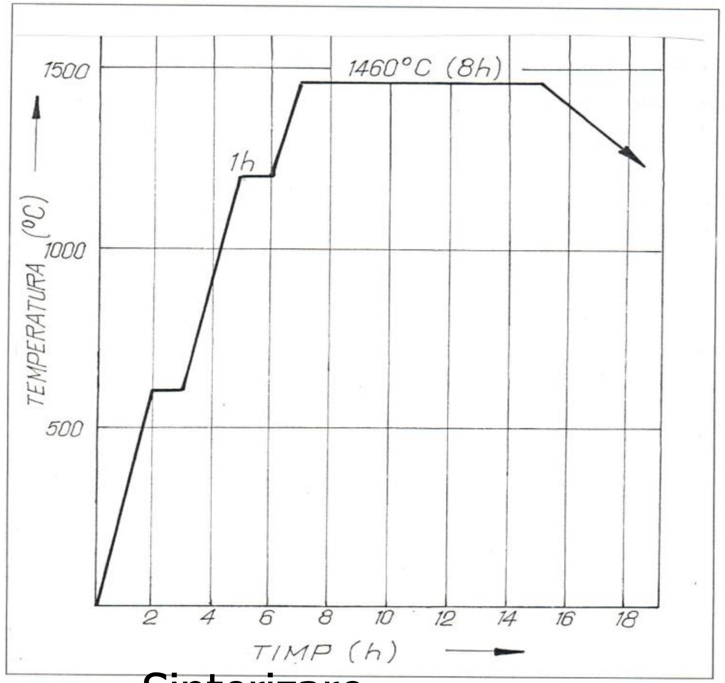
Cretu N- On the behaviour of a ferrimagnetic sample in a microwave field with a determinate geometry, Metallofizika i Noveishie Tekhnologii, 20 (4), 1996 pp. 10-15

Nicolae Cretu-A Method for Estimation of the Magnetization of a Lossless Ferrite in the Microwave Domain, Proc. Of 6th European Magnetic Materials and Applications Conference Wien, Austria, September 4-8, 1995

$$3Y_2O_3 + 5Fe_2O_3 = 2Y_3Fe_5O_{12}$$



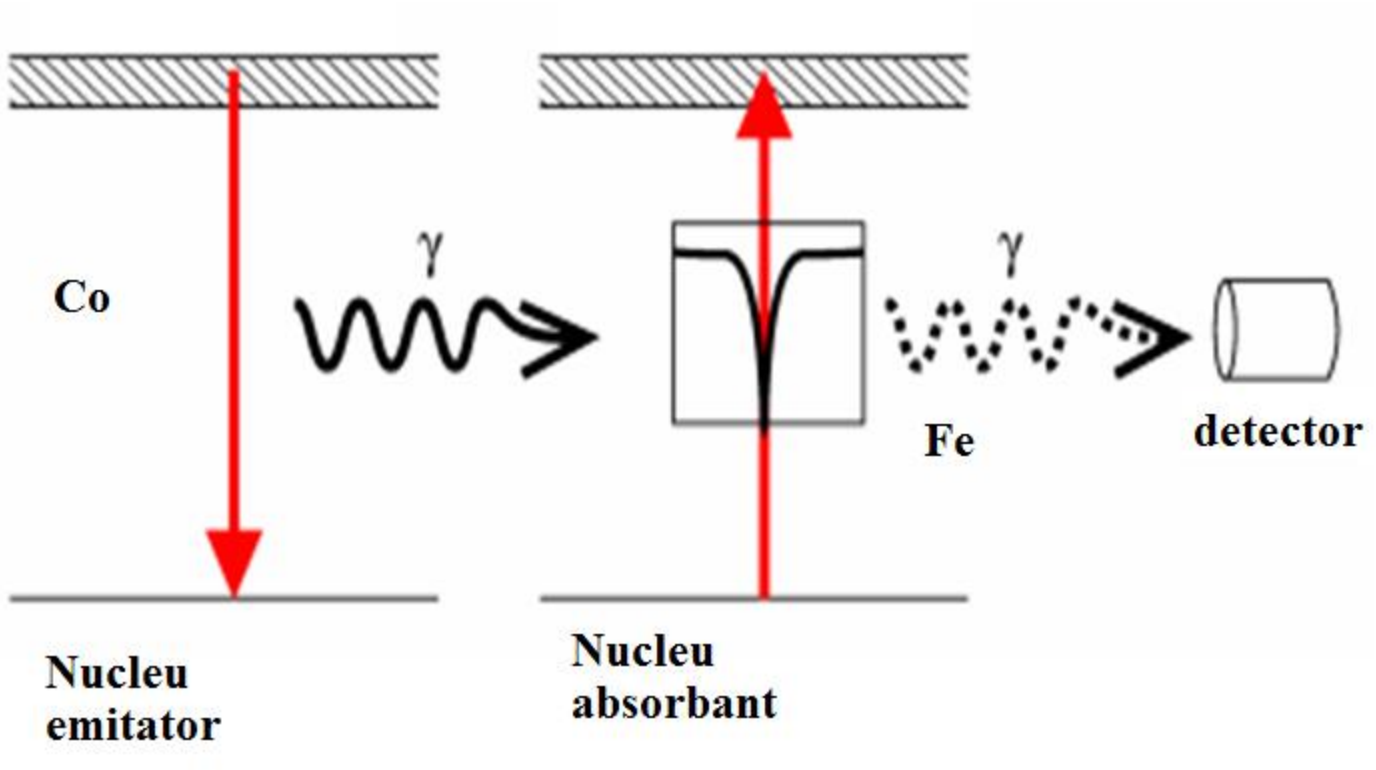
Presinterizare

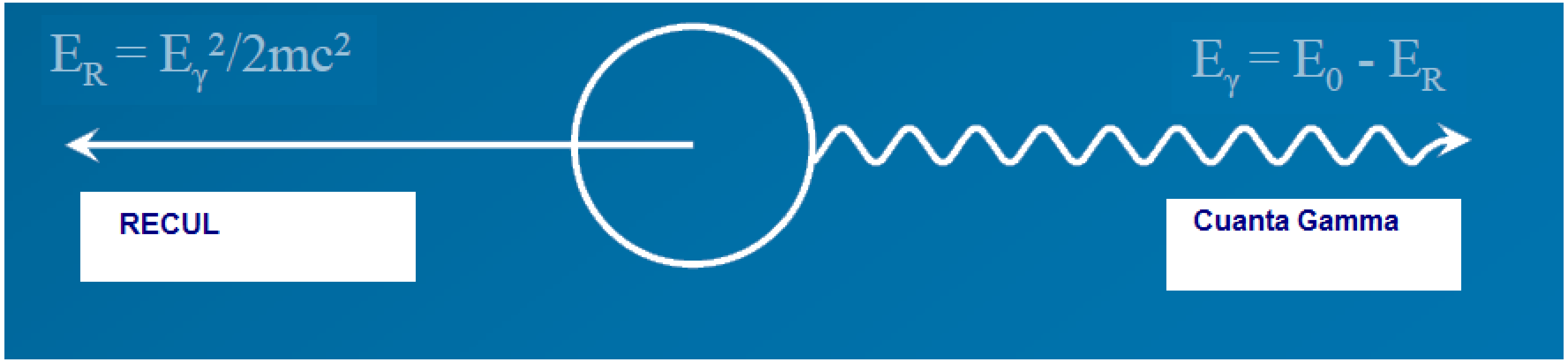


Sinterizare

Studii pe baza efectului Mossbauer:

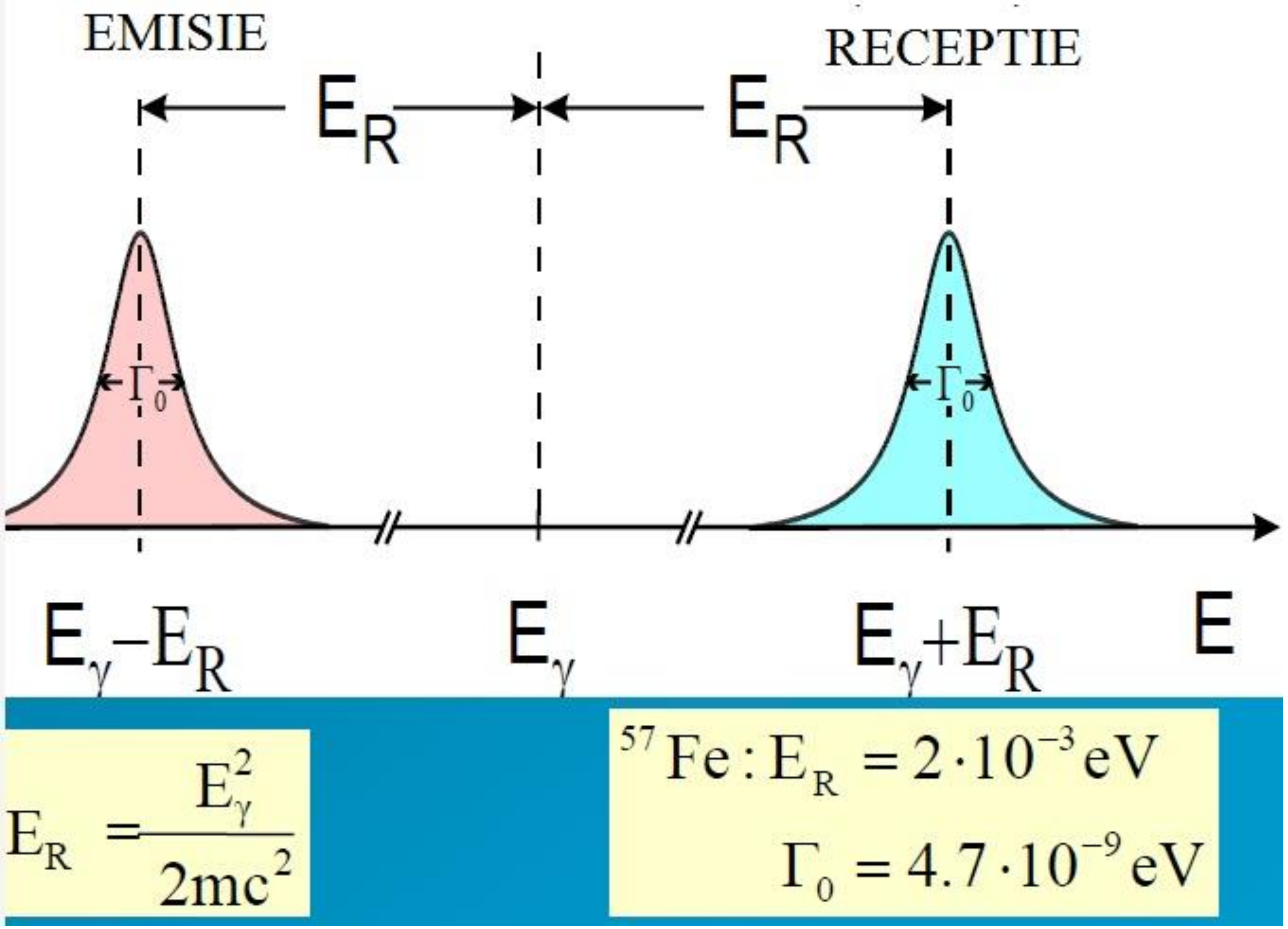
Absorbtie rezonantă





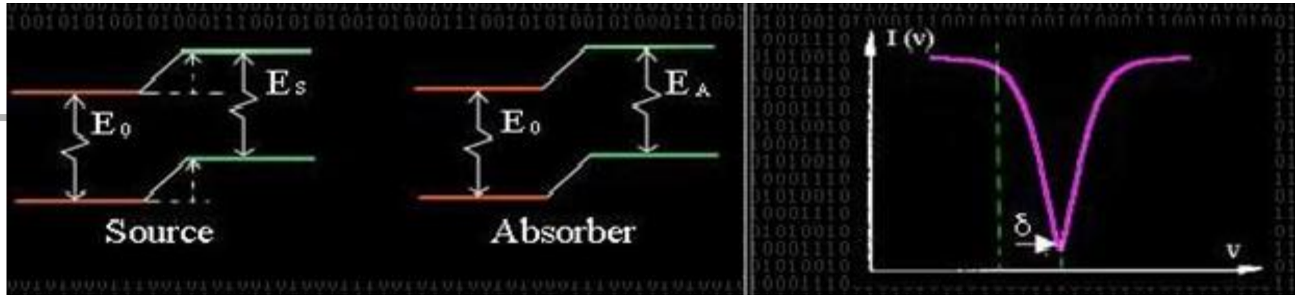
$E_R = E_\gamma^2/2mc^2$
$E_\gamma = E_0 - E_R$
RECUL
Cuanta Gamma

Influenta reculului

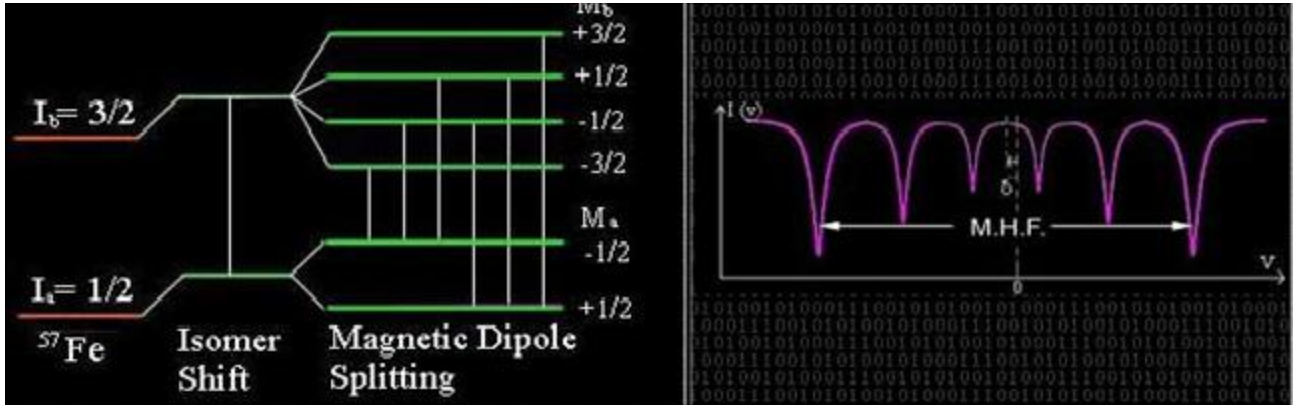


PARAMETRII SPECTRELOR MÖSSBAUER

Deplasarea izomera

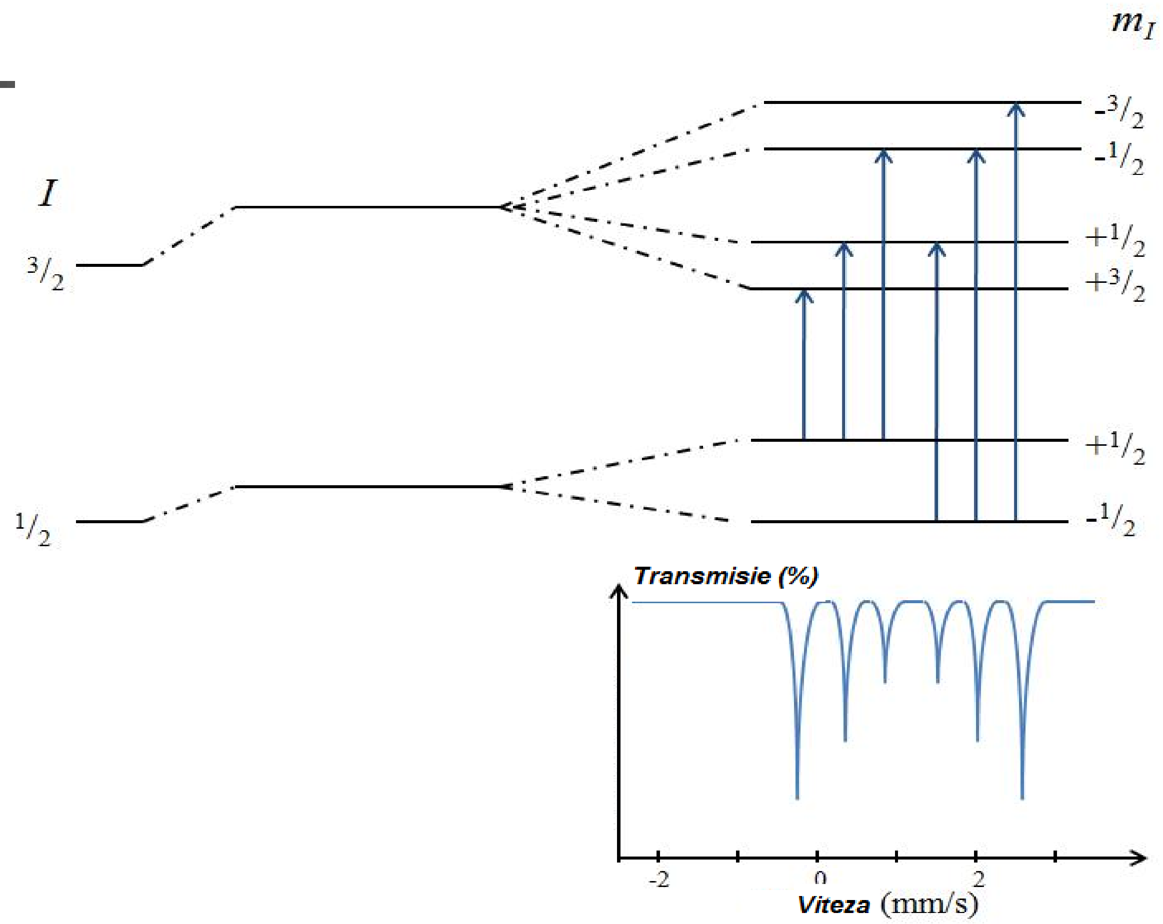


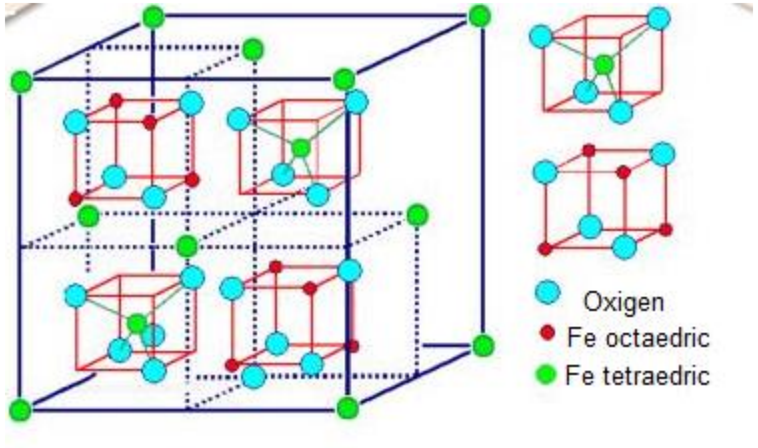
Campul magnetic
la nucleu-Efect
Zeeman nuclear



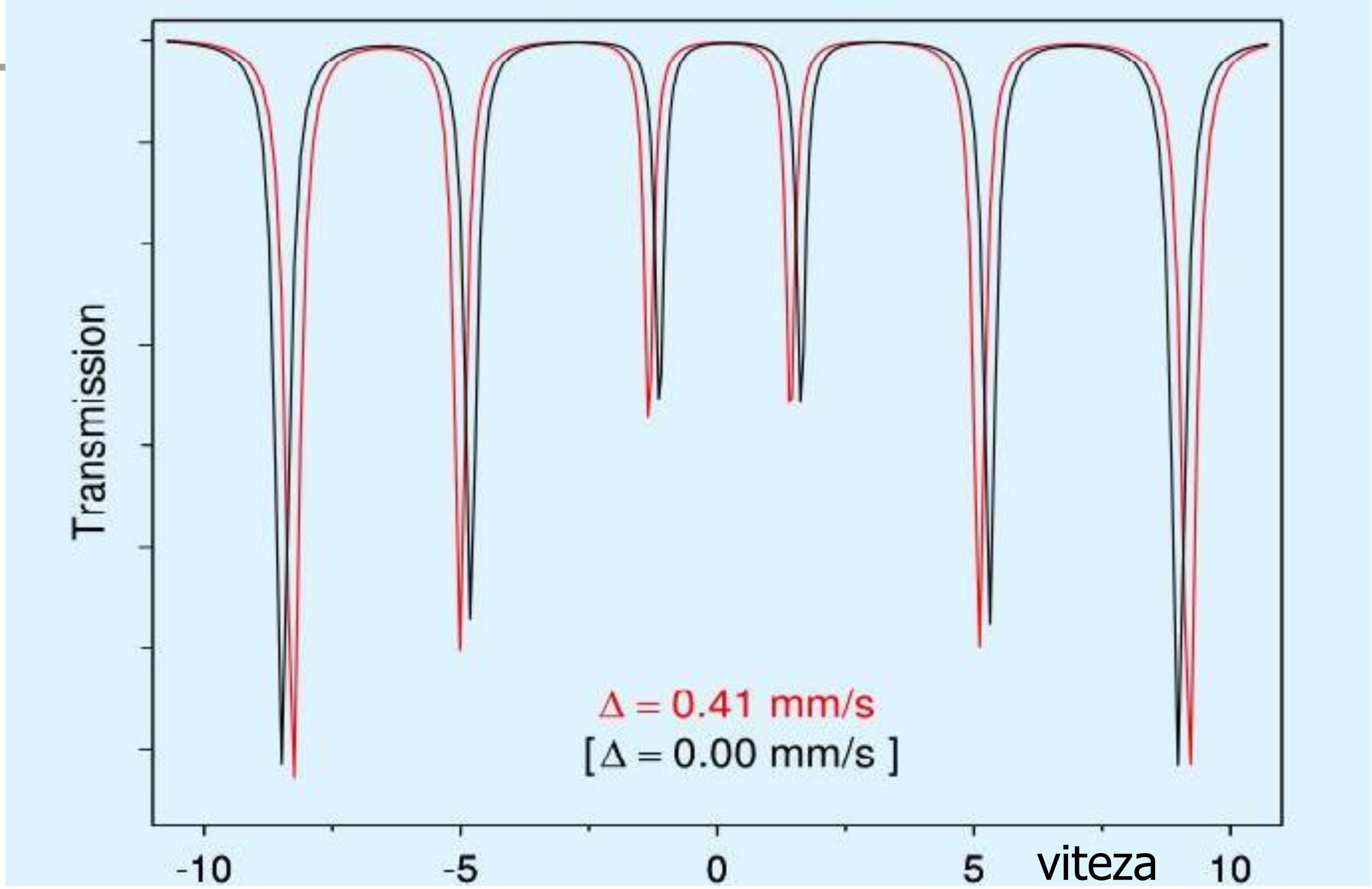
Despicarea
cuadrupolara

Spectrul Mössbauer

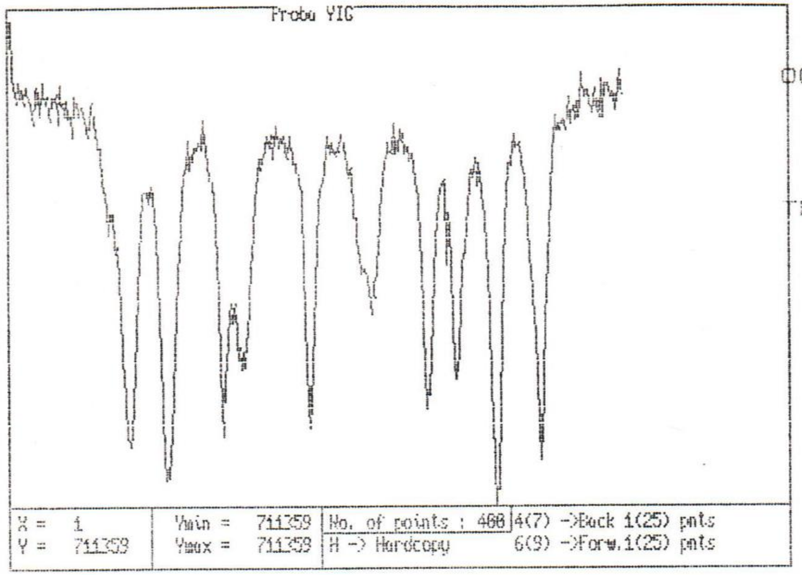




ferite spinelice



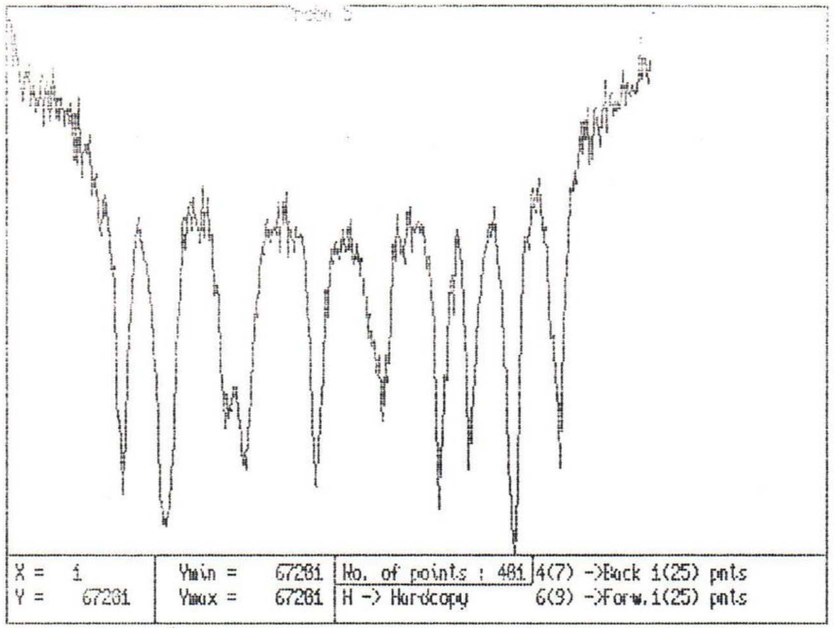
Proba YIG



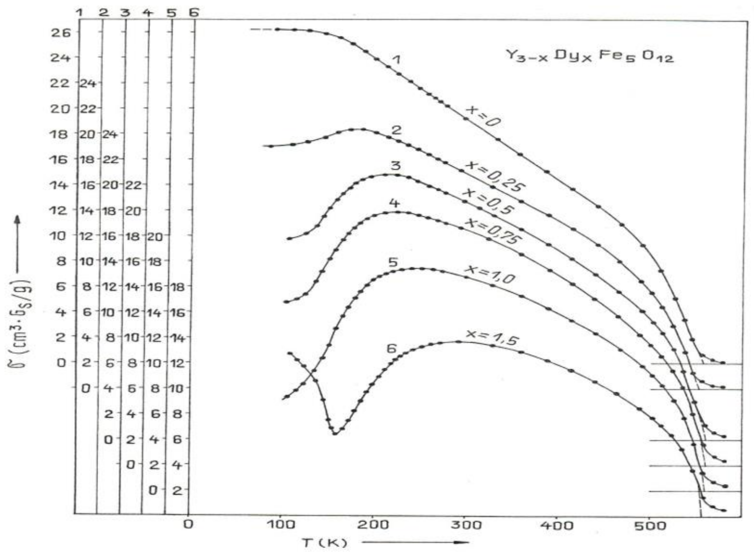
OCTAEDRIC
δ=0.362mm/s
H=15.774mm/s
ε=0.033mm/s

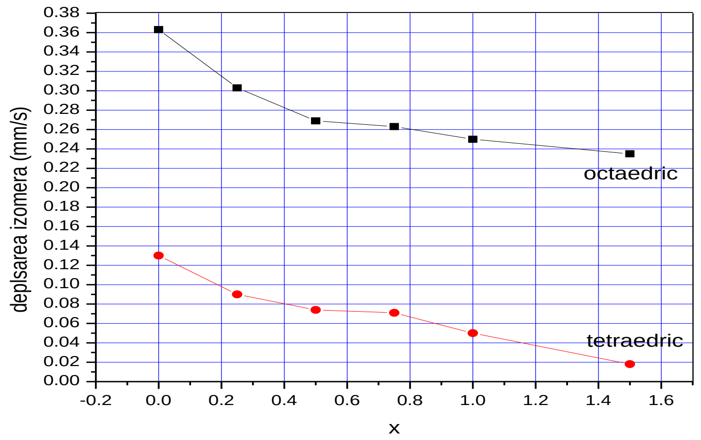
TETRAEDRIC
δ= 0.137mm/s
H=12.902mm/s
ε= 0.052mm/s

Proba $Y_2DyFe_5O_{12}$



OCTAEDRIC	TETRAEDRIC
δ= 0.250 mm/s	δ= 0.050 mm/s
H=15.872 mm/s	H=12.927 mm/s
ε= 0.062 mm/s	ε= 0.042 mm/s





Studiul proprietăţilor elastice ale materialelor

Robert Oberle and R. C. Cammarata, Acoustic pulse propagation in elastically inhomogeneous media, ***J.Acoust.Soc.Am.****94,2947 (1993)*

Metoda dezvoltarii in serie pentru un mediu omogen

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$$\tilde{u}(x,\omega)=\frac{1}{2\pi}\int_{-\infty}^{+\infty}u\,(x,t)\cdot e^{i\omega t}dt$$

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$$\tilde{u}(x,\omega) = \sum_{n=0}^{\infty} c_n(\omega) \cdot x^n$$

$$\frac{\partial \tilde{u}}{\partial x} = \sum_{n=1}^{\infty} n \cdot c_n \cdot x^{n-1} = \sum_{n=0}^{\infty} (n+1) \cdot c_{n+1} \cdot x^n \qquad \frac{\partial^2 \tilde{u}}{\partial x^2} = \sum_{n=0}^{\infty} (n+1)(n+2) c_{n+2} \cdot x^n$$

$$c_{n+2} = -\frac{\omega^2}{v^2} \cdot \frac{1}{(n+1)(n+2)} c_n$$

Conditii initiale:

$$\tilde{u}(0,\omega) = c_0$$

$$c_1 = \frac{\partial \tilde{u}(x,\omega)}{\partial x}\Big|_{x=0} = -\frac{i\omega}{v} c_0$$

N.Cretu, *P.P.Delsanto,G.Nita,C.Rosca, M.Scalerandi,I.Sturzu-Ultrasonic pulse propagation in inhomogeneous one-dimensional media-* ***J.Acoust.Soc.Am.****104 (1) (1998) 57-63*

Scalerandi M, ***Cretu N****, Chiriacescu S, Sturzu I, Rosca I.C., Method for simulation of Gaussian pulse propagation in an elastic medium with periodical inhomogeneity,* ***International Conference on Computational Acoustics and its Environmenatal Applications, COMPAC****, Proceedings 1997, Pages 161-168, Proceedings of the 2nd International Conference on Computational Acoustics and its Environmental Applications, COMPAC; Acquasparta, Italy; 1 June 1997 through 1 June 1997; Code 46965 N.*

N.Cretu*, G. Nita, I. Sturzu, C. Rosca, A semi-analytic method for the study of acoustic pulse propagation in 1-D inhomogeneous elastic media,* ***Integral Methods in Science and Engineering, Chapman&Hall/*** *CRC, ISBN 1-58488-146-1, 2000,107-113*

Puls gaussian în timp

$$u(0,t) = A \cdot e^{-at^2}$$

$$\tilde{u}(0,\omega) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} u(0,t)e^{-i\omega t}dt = \frac{A}{2\pi}\int_{-\infty}^{+\infty} e^{-a(t+\frac{i\omega}{2a})^2} \cdot e^{-\frac{\omega^2}{4a}}dt =$$

$$= \frac{A}{2a\sqrt{\pi}} e^{-\frac{\omega^2}{4a}}$$

$$c_0 = \frac{A}{2a\sqrt{\pi}} e^{-\frac{\omega^2}{4a}}$$

$$c_1 = \frac{\partial \tilde{u}(x,\omega)}{\partial x}\Big|_{x=0} = -\frac{i\omega}{v}c_0$$

N.Cretu, *P.P.Delsanto, G.Nita, C.Rosca, M.Scalerandi, I.Sturzu-Ultrasonic pulse propagation in inhomogeneous one-dimensional media-* ***J.Acoust.Soc.Am.*** *104 (1) (1998) 57-63*

Scalerandi M, ***Cretu N***, *Chiriacescu S, Sturzu I, Rosca I.C., Method for simulation of Gaussian pulse propagation in an elastic medium with periodical inhomogeneity,* ***International Conference on Computational Acoustics and its Environmenatal Applications, COMPAC***, *Proceedings 1997, Pages 161-168, Proceedings of the 2nd International Conference on Computational Acoustics and its Environmental Applications, COMPAC; Acquasparta, Italy; 1 June 1997 through 1 June 1997; Code 46965 N.*

N.Cretu, *G. Nita, I. Sturzu, C. Rosca, A semi-analytic method for the study of acoustic pulse propagation in 1-D inhomogeneous elastic media,* ***Integral Methods in Science and Engineering, Chapman&Hall***/ *CRC, ISBN 1-58488-146-1, 2000,107-113*

Implementare numerica-discretizarea mediului

$$\delta x = x_{k+1} - x_k \qquad\qquad x_k = x_0 + k \cdot \delta x$$

$$\tilde{u}(x_k, \omega) = \sum_{n=0}^{N} c_n{}^k \cdot \delta x^n$$

$$c_0^k = \begin{cases} \tilde{u}(x_0, \omega), & k = 0 \\ \sum_{n=0}^{N} c_n^{k-1} \cdot \delta x^n, & k > 0 \end{cases}$$

$$c_1^k = \begin{cases} \dfrac{i\omega}{c} \cdot c_0^k, & k = 0 \\ \sum_{n=0}^{N} n \cdot c_n^{k-1} \cdot \delta x^{n-1}, & k > 0 \end{cases}$$

N.Cretu, *P.P.Delsanto,G.Nita,C.Rosca, M.Scalerandi,I.Sturzu-Ultrasonic pulse propagation in inhomogeneous one-dimensional media-* ***J.Acoust.Soc.Am.*** *104 (1) (1998) 57-63*

Scalerandi M, ***Cretu N****, Chiriacescu S, Sturzu I, Rosca I.C., Method for simulation of Gaussian pulse propagation in an elastic medium with periodical inhomogeneity,* ***International Conference on Computational Acoustics and its Environmenatal Applications,*** *COMPAC, Proceedings 1997, Pages 161-168, Proceedings of the 2nd International Conference on Computational Acoustics and its Environmental Applications, COMPAC; Acquasparta, Italy; 1 June 1997 through 1 June 1997; Code 46965 N.*

N.Cretu*, G. Nita, I. Sturzu, C. Rosca, A semi-analytic method for the study of acoustic pulse propagation in 1-D inhomogeneous elastic media,* ***Integral Methods in Science and Engineering, Chapman&Hall/*** *CRC, ISBN 1-58488-146-1, 2000,107-113*

Generalizarea metodei: functiile de neomogenitate

$$\partial_x\left(g(x)\cdot\partial_x\tilde{u}(x,\omega)\right)=-\omega^2\cdot f(x)\cdot\tilde{u}(x,\omega)$$

$$f(x)=f_0(1+\eta_1\cdot p(x)) \qquad g(x)=g_0(1+\eta_2\cdot q(x))$$

$$p(x)=\sum_{n=0}^{\infty}a_n(x-x_0)^n,\quad a_n=\frac{1}{n!}\partial_x^n(p(x))\Big|_{x=x_0} \qquad q(x)=\sum_{n=0}^{\infty}b_n(x-x_0)^n,\quad b_n=\frac{1}{n!}\cdot\partial_x^n(q(x))\Big|_{x=x_0}$$

$$\tilde{u}(x,\omega)=\sum_{n=0}^{\infty}c_n(\omega)(x-x_0)^n, \qquad c_n=\frac{1}{n!}\cdot\partial_x^n(\tilde{u}(x,\omega))\Big|_{x=x_0}$$

$$c_{n+2}=-\frac{1}{(n+2)(n+1)[1+\eta_2 q(x_0)]}\cdot\left\{\left[1+\eta_1 p(x_0)\cdot\left(\frac{\omega}{c}\right)^2\right]\cdot c_n+\sum_{m=1}^{n+1}\left[\eta_1 a_m\left(\frac{\omega}{c}\right)^2 c_{n-m}+\eta_2 b_m(m+1)(n-m+2)c_{n-m+2}\right]\right\}$$

N.Cretu,*P.P.Delsanto,G.Nita,C.Rosca, M.Scalerandi,I.Sturzu-Ultrasonic pulse propagation in inhomogeneous one-dimensional media- J.Acoust.Soc.Am.104 (1) (1998) 57-63*

Scalerandi M, ***Cretu N****, Chiriacescu S, Sturzu I, Rosca I.C., Method for simulation of Gaussian pulse propagation in an elastic medium with periodical inhomogeneity, International Conference on Computational Acoustics and its Environmenatal Applications, COMPAC, Proceedings 1997, Pages 161-168, Proceedings of the 2nd International Conference on Computational Acoustics and its Environmental Applications, COMPAC; Acquasparta, Italy; 1 June 1997 through 1 June 1997; Code 46965 N.*

N.Cretu*, G. Nita, I. Sturzu, C. Rosca, A semi-analytic method for the study of acoustic pulse propagation in 1-D inhomogeneous elastic media, Integral Methods in Science and Engineering, Chapman&Hall/ CRC, ISBN 1-58488-146-1, 2000,107-113*

Cazul mediilor armonice:

$$f(x)=\sum_{i-0}^{\infty}\left(\alpha_i\cdot\cos k_i x+\beta_i\sin k_i x\right)\qquad g(x)=\sum_{i-0}^{\infty}\left(\gamma_i\cdot\cos k_i x+\eta_i\sin k_i x\right)$$

$$\sin x=\sum_{m=0}^{\infty}\frac{(-1)^m x^{2m+1}}{(2m+1)!};\quad \cos x=\sum_{m=0}^{\infty}\frac{(-1)^m x^{2m}}{(2m)!}$$

$$f(x)=\sum_{m=0}^{\infty}\frac{(-1)^m}{(2m)!}\cdot\left(A_m+xB_m\right)\cdot x^{2m}\qquad g(x)=\sum_{m=0}^{\infty}\frac{(-1)^m}{(2m)!}\cdot\left(C_m+xD_m\right)\cdot x^{2m}$$

$$c_2 = \frac{-1}{2C_0}\left(\omega^2 A_0 c_0 + D_0 c_1\right)$$

$$c_3 = \frac{-1}{6C_0}\left[\omega^2 B_0 c_0 + \left(\omega^2 A_0 - C_1\right)c_1 + 4D_0 c_2\right]$$

$$c_{2n+2} = -\frac{1}{C_0(2n+1)(2n+2)}\Big\{\omega^2\left(A_0 c_{2n} + \omega^2 B_0 c_{2n-1}\right) + (2n+1)^2 D_0 c_{2n+1} +$$

$$+\sum_{m=1}^{n}\frac{(-1)^m}{(2m)!}\Big\{\omega^2\left(A_m c_{2n-2m} + B_m c_{2n-2m-1}\right) +$$

$$+(2n+1)\left[C_m \cdot c_{2n-2m+2}(2n-2m+2) + D_m c_{2n-2m+1}(2n-2m+1)\right]\Big\}\Big\}$$

$$c_{2n+3} = -\frac{1}{C_0(2n+3)(2n+2)}\cdot$$

$$\cdot\Big\{\omega^2\left(A_0 c_{2n+1} + B_0 c_{2n}\right) + (2n+2)^2 D_0 c_{2n+2} + \frac{(-1)^{n+1}}{(2n+1)!}C_{n+1}c_1 +$$

$$+\sum_{m=1}^{n}\frac{(-1)^m}{(2m)!}\Big\{\left[C_m c_{2n-2m+3}(2n-2m+3) + D_m c_{2n-2m+2}(2n-2m+2)\right](2n+2) +$$

$$+\omega^2\left[A_m c_{2n-2m+1} + B_m c_{2n-2m}\right]\Big\}\Big\}$$

H:\Puls\Pulsuri in medii neomogene.vi

-limitele metodei-medii semiinfinite, neomogenitate descrisa de o functie continua

-se impune un control riguros al erorilor care se propaga de la o iteratie la alta

N. Cretu, *G. Nita, Pulse propagation in finite elastic inhomogeneous media, Comp. Mat. Sci. 31,(3-4), 2004, 329-336*

N. Cretu, *Acoustic measurements and computational results on material speciments with harmonic variation of the cross section, Ultrasonics, 43(7), 2005, 547-550*

METODA MATRICII DE TRANSFER

$$u_1(x,\omega)=A_1 e^{ik_1x}+B_1 e^{-ik_1x}$$

$$u_2(x,\omega)=A_2 e^{ik_2x}+B_2 e^{-ik_2x}$$

Conditii pe frontiera:

$$A_1+B_1=A_2+B_2$$

$$S_1\sqrt{E_1\rho_1}(A_1-B_1)=S_1\sqrt{E_1\rho_1}(A_2-B_2)$$

$$\begin{pmatrix}A_2\\B_2\end{pmatrix}=D(Z_1,Z_2)\begin{pmatrix}A_1\\B_1\end{pmatrix}$$

$$D(Z_1,Z_2)=\frac{1}{2}\begin{pmatrix}1+\frac{Z_1}{Z_2} & 1-\frac{Z_1}{Z_2}\\ 1-\frac{Z_1}{Z_2} & 1+\frac{Z_1}{Z_2}\end{pmatrix}$$

$$\begin{pmatrix}A'\\B'\end{pmatrix}=P(k,a)\begin{pmatrix}A\\B\end{pmatrix}\qquad P(k,a)=\begin{pmatrix}e^{ika} & 0\\ 0 & e^{-ika}\end{pmatrix}$$

N. Cretu, *G. Nita, Pulse propagation in finite elastic inhomogeneous media, Comp. Mat. Sci. 31,(3-4), 2004, 329-336*

N. Cretu, *Acoustic measurements and computational results on material speciments with harmonic variation of the cross section, Ultrasonics, 43(7), 2005, 547-550*

Cazul unui mediu omogen de lungime l:

$$\begin{pmatrix} A_{out}(\omega) \\ B_{out}(\omega) \end{pmatrix} = \frac{1}{4} \cdot \begin{pmatrix} 1+\frac{Z_1}{Z_{out}} & 1-\frac{Z_1}{Z_{out}} \\ 1-\frac{Z_1}{Z_{out}} & 1+\frac{Z_1}{Z_{out}} \end{pmatrix} \cdot \begin{pmatrix} e^{ik'l} & 0 \\ 0 & e^{-ik'l} \end{pmatrix} \cdot \begin{pmatrix} 1+\frac{Z_{in}}{Z_1} & 1-\frac{Z_{in}}{Z_1} \\ 1-\frac{Z_{in}}{Z_1} & 1+\frac{Z_{in}}{Z_1} \end{pmatrix} \cdot \begin{pmatrix} A_{in}(\omega) \\ B_{in}(\omega) \end{pmatrix}$$

Cazul unui mediu stratificat format din N straturi:

$$T(Z_L, Z_R) = \left[\prod_{j=0}^{N-1} D\left(Z_{N-1-j}, Z_{N-j}\right) P\left(k_{N-1-j}, a_{N-1-j}\right) \right] D(Z_{-1}, Z_0)$$

N. Cretu, *G. Nita, Pulse propagation in finite elastic inhomogeneous media, Comp. Mat. Sci. 31,(3-4), 2004, 329-336*

N. Cretu, *Acoustic measurements and computational results on material speciments with harmonic variation of the cross section, Ultrasonics, 43(7), 2005, 547-550*

Aplicarea formalismului matricial la reconstrucţia undelor

$$U_{injected}(0,t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} A(\omega) e^{-i\omega t}\, d\omega$$

$$U_{rejected}(0,t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} B(\omega) e^{-i\omega t}\, d\omega$$

$$U_{transferred}(L,t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} C(\omega) e^{-i\omega t}\, d\omega$$

$$\begin{pmatrix} A(\omega) \\ B(\omega) \end{pmatrix} = T(Z_R, Z_L, \omega)\begin{pmatrix} C(\omega) \\ 0 \end{pmatrix}$$

$$C(\omega) = \frac{1}{a(\omega)} A(\omega)$$

$$B(\omega) = \frac{b(\omega)}{a(\omega)} A(\omega)$$

$$t(\omega) = \frac{1}{a(\omega)}$$

$$r(\omega) = \frac{b(\omega)}{a(\omega)}$$

$$U_{rejected}(t) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} r(\omega) \left[\int_{-\infty}^{+\infty} U_{injected}(t) e^{i\omega\tau} d\tau \right] e^{-i\omega t} d\omega = \int_{-\infty}^{+\infty} U_{injected}(t) \tilde{r}(t-\tau) d\tau$$

$$U_{transferred}(t) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} t(\omega) \left[\int_{-\infty}^{+\infty} U_{injected}(t) e^{i\omega\tau} d\tau \right] e^{-i\omega t} d\omega = \int_{-\infty}^{+\infty} U_{injected}(t) \tilde{t}(t-\tau) d\tau$$

$$T(\omega) = \frac{\frac{dW_{transfered}}{dt}}{\frac{dW_{injected}}{dt}} = \frac{Z_{out}|C(\omega)|^2}{Z_{in}|A(\omega)|^2}$$

$$T(\omega) = 1 - \frac{|b(\omega)|^2}{|a(\omega)|^2}$$

$$R(\omega) = \frac{\frac{dW_{rejected}}{dt}}{\frac{dW_{injected}}{dt}} = \frac{|B(\omega)|^2}{|A(\omega)|^2}$$

$$R(\omega) = \frac{|b(\omega)|^2}{|a(\omega)|^2}$$

$$P_T(\omega) = \frac{|C(\omega)|^2}{\int_{-\infty}^{+\infty} |A(\omega)|^2 d\omega} = \frac{T(\omega)|A(\omega)|^2}{\int_{-\infty}^{+\infty} |A(\omega)|^2 d\omega}$$

$$P_R(\omega) = \frac{|B(\omega)|^2}{\int_{-\infty}^{+\infty} |A(\omega)|^2 d\omega} = \frac{R(\omega)|A(\omega)|^2}{\int_{-\infty}^{+\infty} |A(\omega)|^2 d\omega}$$

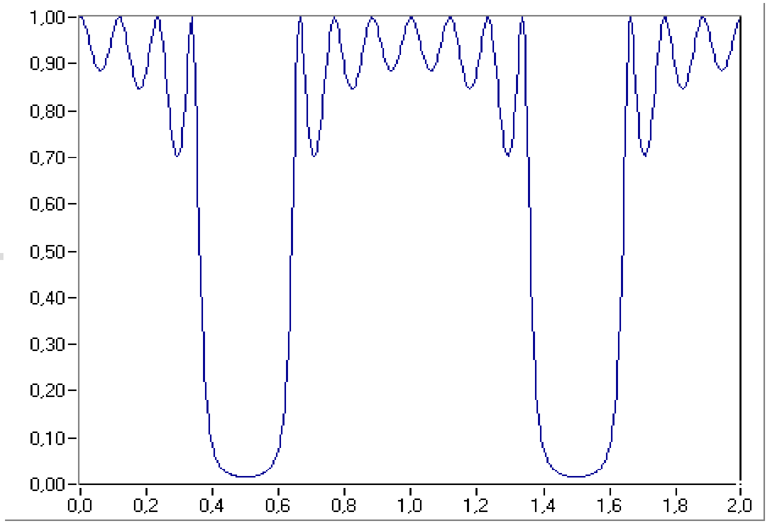
$$a(\omega) = \frac{1}{t(\omega)} = \frac{FFT\left[U(t)_{injected}\right]}{FFT\left[U(t)_{transfered}\right]}$$

$$b(\omega) = \frac{r(\omega)}{t(\omega)} = \frac{FFT\left[U(t)_{rejected}\right]}{FFT\left[U(t)_{transfered}\right]}$$

Mediu periodic

$$Z(x) = Z(x + n\Lambda)$$
$$V(x) = V(x + n\Lambda) \qquad n \in N$$

$$T(\nu) = \frac{Z_{out}|C(\nu)|^2}{Z_{in}|A(\nu)|^2}$$



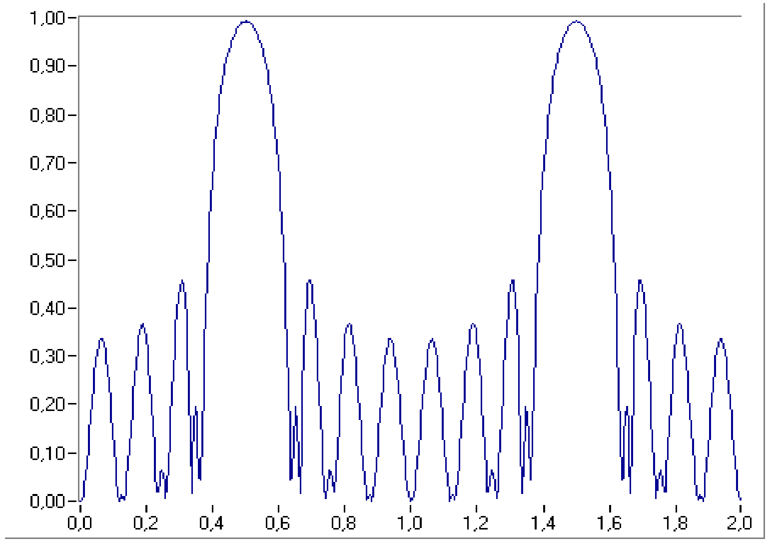
Spectrul puterii transmise

$$x_0 = \Lambda$$

$$t_0 = \frac{x_0}{V_0}$$

$$\nu_0 = \frac{V_0}{x_0}$$

$$R(\nu) = \frac{|B(\nu)|^2}{|A(\nu)|^2}$$



Spectrul puterii reflectate

Cretu N, *Nita G, A simplified modal analysis based on the properties of the transfer matrix, Mechanics of Materials, 60 ,2013, 121-128*
Cretu N, *Nita G, Pop M, Wave transmission approach based on the modal analysis for embedded mechanical systems, Journal of Sound and Vibration, 332 (20),2013,4940-4947*
Cretu N, *Pop M, Rosca C, Eigenvalues and eigenvectors of the transfer matrix, AIP Conference Proceedings, 1433, 2012, 535-538 (International Congress on Ultrasonics ICU 2011, Gdansk, Poland, 3-8 September 2011)-oral presentation*

MATRICEA INTRINSECĂ DE TRANSFER

$$\begin{pmatrix} A_{out}(\omega,l) \\ B_{out}(\omega,l) \end{pmatrix} = D(Z_1, Z_{out}) \cdot P(k,l) \cdot D(Z_{in}, Z_1) \begin{pmatrix} A_{in}(\omega,0) \\ B_{in}(\omega,0) \end{pmatrix}$$

Cazul unei unde stationare:

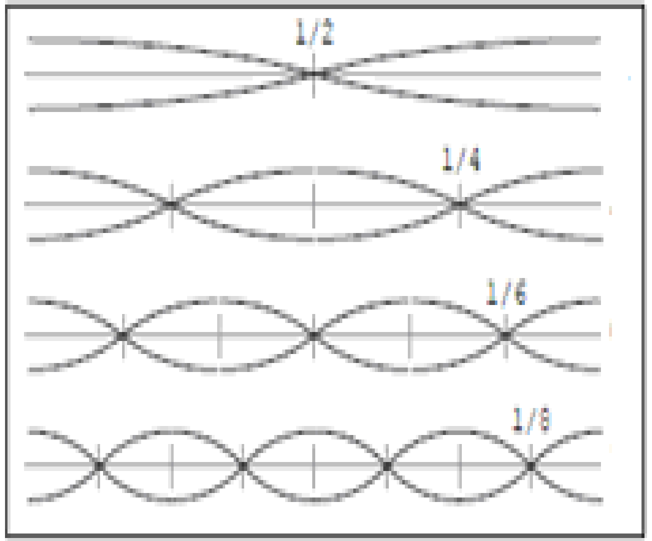
$$\begin{pmatrix} A''(\omega,l) \\ B''(\omega,l) \end{pmatrix} = P(k,l) \begin{pmatrix} A'(\omega,0) \\ B'(\omega,0) \end{pmatrix}$$

Valorile proprii ale matricii de propagare:

$$\lambda = \cos kl + i \cdot \sin kl$$

$$\lambda = \mp 1$$

$$\sin kl = 0, \Rightarrow \cos kl = \pm 1 \Leftrightarrow kl = n\pi, \quad l = n\frac{\lambda_w}{2}$$



Cretu N, *Nita G, A simplified modal analysis based on the properties of the transfer matrix, Mechanics of Materials, 60 ,2013, 121-128*

Cretu N, *Nita G, Pop M, Wave transmission approach based on the modal analysis for embedded mechanical systems, Journal of Sound and Vibration, 332 (20),2013,4940-4947*

Cretu N, *Pop M, Rosca C, Eigenvalues and eigenvectors of the transfer matrix, AIP Conference Proceedings, 1433, 2012, 535-538 (International Congress on Ultrasonics ICU 2011, Gdansk, Poland, 3-8 September 2011)-oral presentation*

SISTEME ELASTICE BINARE

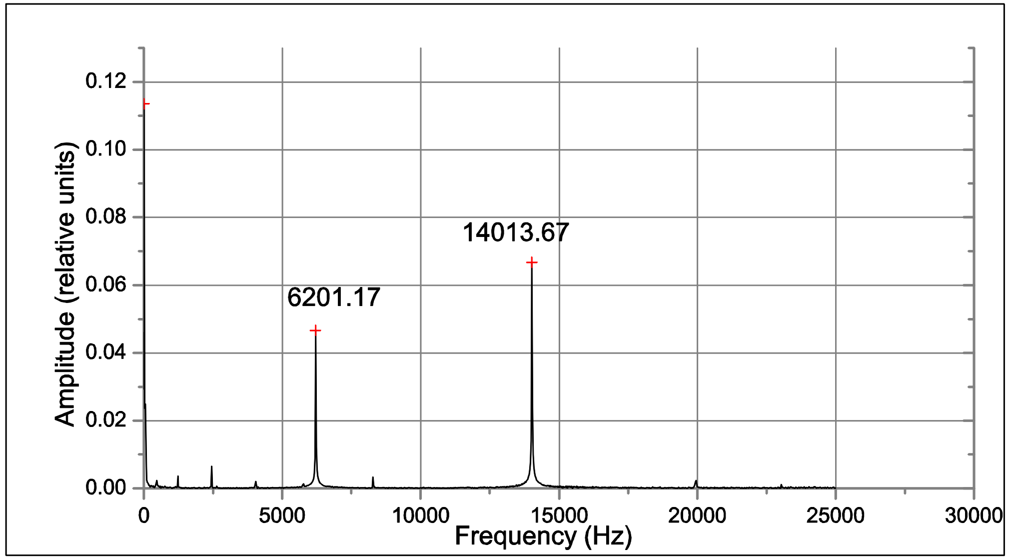
$$T(\omega) = \frac{1}{2}\begin{pmatrix} (\frac{Z_1}{Z_2}+1)\cdot e^{i(k_1 l_1 + k_2 l_2)} & (\frac{Z_1}{Z_2}-1)e^{-i(k_1 l_1 - k_2 l_2)} \\ (\frac{Z_1}{Z_2}-1)\cdot e^{i(k_1 l_1 - k_2 l_2)} & (\frac{Z_1}{Z_2}+1)e^{-i(k_1 l_1 + k_2 l_2)} \end{pmatrix}$$

$$\lambda_{1,2} = \frac{1}{2}(\frac{c_1\rho_1}{c_2\rho_2}+1)\cdot\cos\left(\omega\cdot\frac{l_1c_2+l_2c_1}{c_1c_2}\right) \pm \frac{1}{2}\sqrt{(\frac{c_1\rho_1}{c_2\rho_2}+1)^2\cdot\cos^2\left(\omega\cdot\frac{l_1c_2+l_2c_1}{c_1c_2}\right) - 4\frac{c_1\rho_1}{c_2\rho_2}}$$

$$\lambda_{12} = \pm\sqrt{\frac{c_1\rho_1}{c_2\rho_2}}$$

Posibilitatea determinarii vitezei de faza in medii elastice

Cretu N, *Nita G, A simplified modal analysis based on the properties of the transfer matrix, Mechanics of Materials, 60 ,2013, 121-128*
Cretu N, *Nita G, Pop M, Wave transmission approach based on the modal analysis for embedded mechanical systems, Journal of Sound and Vibration, 332 (20),2013,4940-4947*
Cretu N, *Pop M, Rosca C, Eigenvalues and eigenvectors of the transfer matrix, AIP Conference Proceedings, 1433, 2012, 535-538 (International Congress on Ultrasonics ICU 2011, Gdansk, Poland, 3-8 September 2011)-oral presentation*



Frecvenţa modurilor proprii pentru sistemul binar alama-aluminiu

Cretu N, *Nita G, A simplified modal analysis based on the properties of the transfer matrix, Mechanics of Materials, 60 ,2013, 121-128*
Cretu N, *Nita G, Pop M, Wave transmission approach based on the modal analysis for embedded mechanical systems, Journal of Sound and Vibration, 332 (20),2013,4940-4947*
Cretu N, *Pop M, Rosca C, Eigenvalues and eigenvectors of the transfer matrix, AIP Conference Proceedings, 1433, 2012, 535-538 (International Congress on Ultrasonics ICU 2011, Gdansk, Poland, 3-8 September 2011)-oral presentation*

CAZUL SISTEMELOR TERNARE

$$T(\omega) = \frac{1}{4} \cdot \begin{pmatrix} e^{ik_3 l_3} & 0 \\ 0 & e^{-ik_3 l_3} \end{pmatrix} \cdot \begin{pmatrix} 1+\frac{Z_2}{Z_3} & 1-\frac{Z_2}{Z_3} \\ 1-\frac{Z_2}{Z_3} & 1+\frac{Z_2}{Z_3} \end{pmatrix} \cdot \begin{pmatrix} e^{ik_2 l_2} & 0 \\ 0 & e^{-ik_2 l_2} \end{pmatrix} \cdot \begin{pmatrix} 1+\frac{Z_1}{Z_2} & 1-\frac{Z_1}{Z_2} \\ 1-\frac{Z_1}{Z_2} & 1+\frac{Z_1}{Z_2} \end{pmatrix} \cdot \begin{pmatrix} e^{ik_1 l_1} & 0 \\ 0 & e^{-ik_1 l_1} \end{pmatrix}$$

$$\lambda_{1,2} = \left\{ \left(\frac{Z_1+Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \cdot \cos(k_1 l_1 + k_2 l_2 + k_1 l_3) - \left(\frac{Z_1-Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \cdot \cos(k_1 l_1 - k_2 l_2 + k_1 l_3) \right\} \pm \sqrt{\left\{ \left(\frac{Z_1+Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \cdot \cos(k_1 l_1 + k_2 l_2 + k_1 l_3) - \left(\frac{Z_1-Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \cdot \cos(k_1 l_1 - k_2 l_2 + k_1 l_3) \right\}^2 - 1}$$

$$\left\{ \left(\frac{\rho_1 c_1 + \rho_2 c_2}{2\sqrt{\rho_1 \rho_2 c_1 c_2}} \right)^2 \cdot \cos(k_1 l_1 + k_2 l_2 + k_1 l_3) - \left(\frac{\rho_1 c_1 - \rho_2 c_2}{2\sqrt{\rho_1 \rho_2 c_1 c_2}} \right)^2 \cdot \cos(k_1 l_1 - k_2 l_2 + k_1 l_3) \right\}^2 - 1 = 0$$

Contribuţii şi extinderi ale aplicării matricii intrinseci de transfer

1. Introducerea atenuarii

$$k = \frac{\omega}{c} + i\beta$$

$$TM(\omega) = \frac{1}{4} \cdot \begin{pmatrix} e^{i\frac{\omega}{c_3} l_3 - \beta_3 l_3} & 0 \\ 0 & e^{-i\frac{\omega}{c_3} l_3 + \beta_3 l_3} \end{pmatrix} \cdot \begin{pmatrix} 1+\frac{Z_2}{Z_3} & 1-\frac{Z_2}{Z_3} \\ 1-\frac{Z_2}{Z_3} & 1+\frac{Z_2}{Z_3} \end{pmatrix} \cdot$$

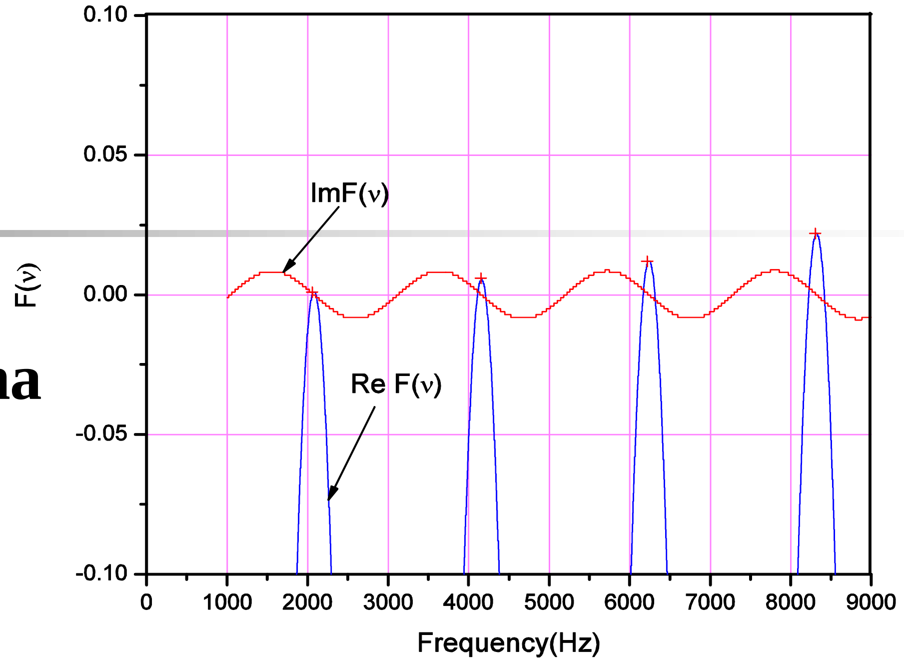
$$\cdot \begin{pmatrix} e^{i\frac{\omega}{c_2} l_2 - \beta_2 l_2} & 0 \\ 0 & e^{-i\frac{\omega}{c_2} l_2 + \beta_2 l_2} \end{pmatrix} \cdot \begin{pmatrix} 1+\frac{Z_1}{Z_2} & 1-\frac{Z_1}{Z_2} \\ 1-\frac{Z_1}{Z_2} & 1+\frac{Z_1}{Z_2} \end{pmatrix} \cdot \begin{pmatrix} e^{i\frac{\omega}{c_1} l_1 - \beta_1 l_1} & 0 \\ 0 & e^{-i\frac{\omega}{c_1} l_1 + \beta_1 l_1} \end{pmatrix}$$

$$\lambda_{1,2}(\omega) = \left[\left(\frac{Z_1 + Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \left[\begin{matrix} \cos\left(\sum_{m=1}^{3} \frac{\omega l_m}{c_m} \right) \cdot \cosh\left(\sum_{m=1}^{3} \beta_m l_m \right) - \\ i \cdot \sin\left(\sum_{m=1}^{3} \frac{\omega l_m}{c_m} \right) \cdot \sinh\left(\sum_{m=1}^{3} \beta_m l_m \right) \end{matrix} \right] \right] -$$

$$\left[\left(\frac{Z_1 - Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \left[\begin{matrix} \cos\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \frac{\omega l_m}{c_m} \right) \cdot \cosh\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \beta_m l_m \right) - \\ i \cdot \sin\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \frac{\omega l_m}{c_m} \right) \cdot \sinh\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \beta_m l_m \right) \end{matrix} \right] \right] \pm \sqrt{F(\omega)}$$

$$F(\omega) = \left\{ \begin{matrix} \left[\left(\frac{Z_1 + Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \left[\begin{matrix} \cos\left(\sum_{m=1}^{3} \frac{\omega l_m}{c_m} \right) \cdot \cosh\left(\sum_{m=1}^{3} \beta_m l_m \right) - \\ i \cdot \sin\left(\sum_{m=1}^{3} \frac{\omega l_m}{c_m} \right) \cdot \sinh\left(\sum_{m=1}^{3} \beta_m l_m \right) \end{matrix} \right] \right] - \\ \left[\left(\frac{Z_1 - Z_2}{2\sqrt{Z_1 Z_2}} \right)^2 \left[\begin{matrix} \cos\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \frac{\omega l_m}{c_m} \right) \cdot \cosh\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \beta_m l_m \right) - \\ i \cdot \sin\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \frac{\omega l_m}{c_m} \right) \cdot \sinh\left(\sum_{m=1}^{3} (-1)^{m+1} \cdot \beta_m l_m \right) \end{matrix} \right] \right] \end{matrix} \right\}^2 - 1$$

Sistem ternar alama-aluminiu-alama

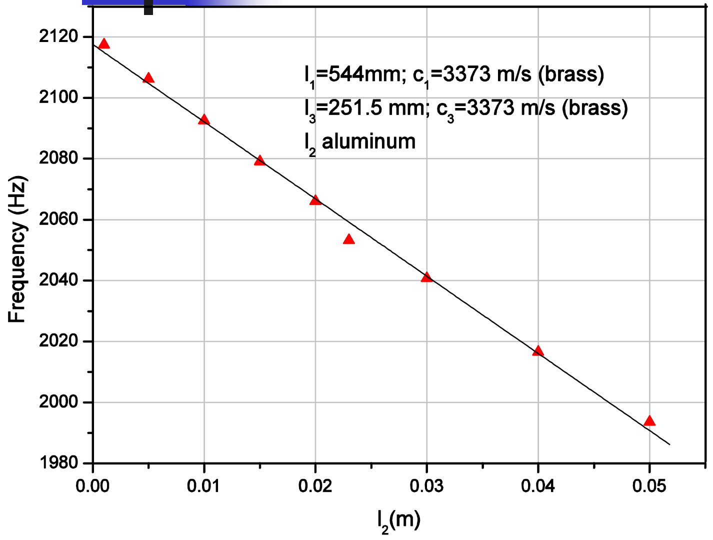


Partile reala si imaginara ale functiei F(ν) in functie de frecventa, pentru sistemul ternar alama-aluminiu-alama

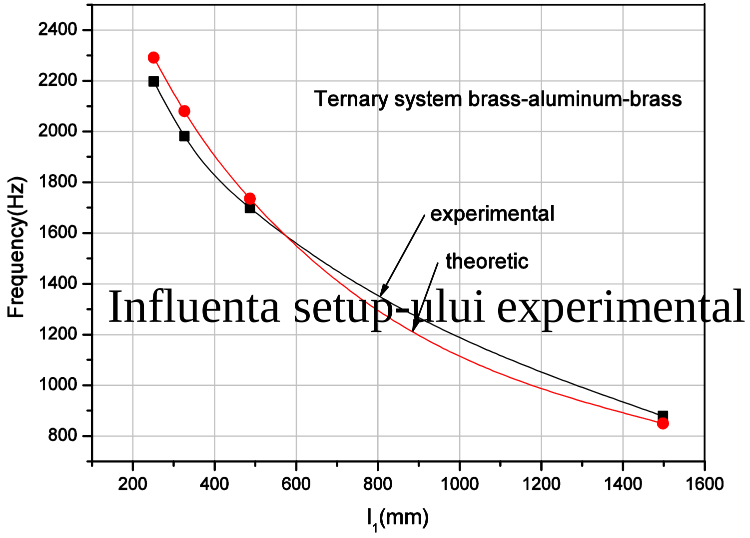
$$l_1 = 544mm, l_2 = 18.16mm, l_3 = 251.5mm, \rho_1 = 8315Kg \cdot m^{-3}, \rho_2 = 2713Kg \cdot m^{-3},$$

$$\beta_1 = 0.01m^{-1}, \beta_2 = 0.011m^{-1}, c_1 = 3372m \cdot s^{-1}, c_2 = 5018m \cdot s^{-1}$$

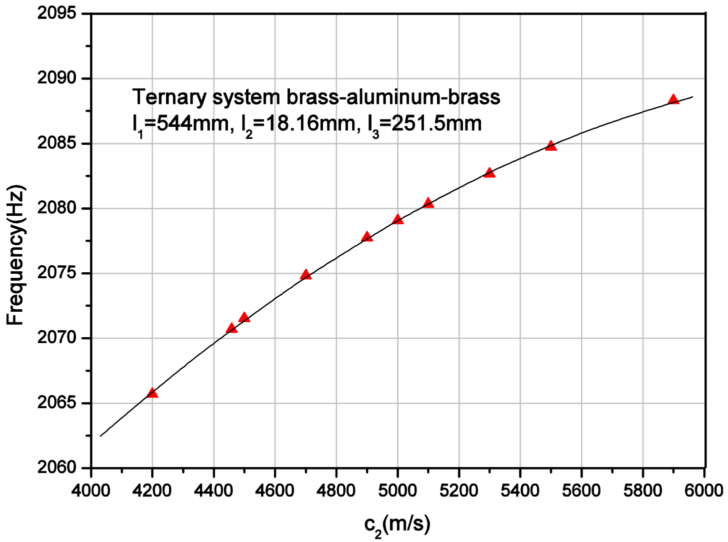
II. Influenta setup-ului experimental



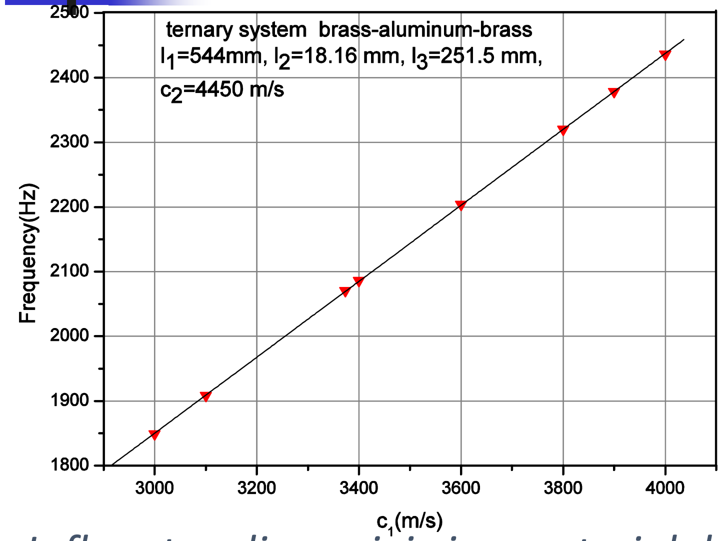
Modificarea frecventei a primului mod propriu al sistemului in functie de lungimea probei de cercetat l2



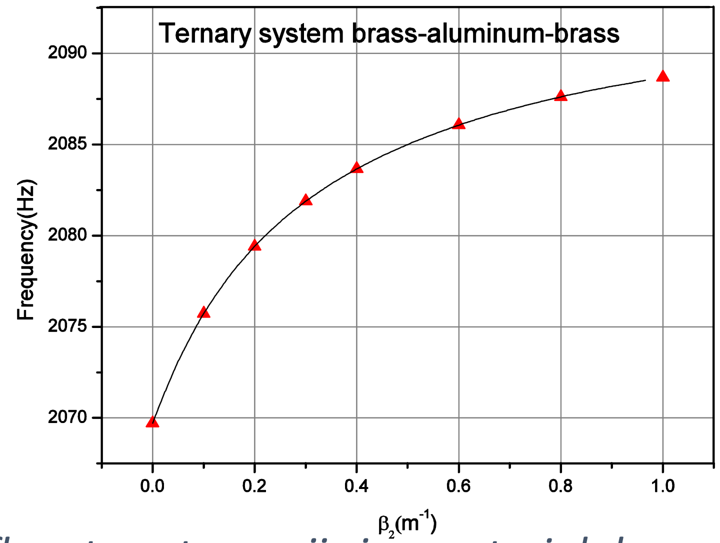
Curbele teoretica si experimentala a modificarii frecventei in functie de lungimea l1 a materialului etalon.



Influenta dispersiei in materialul de cercetat asupra modificarii frecventei modului propriu fundamental al sistemului ternar alama-aluminiu-alama.

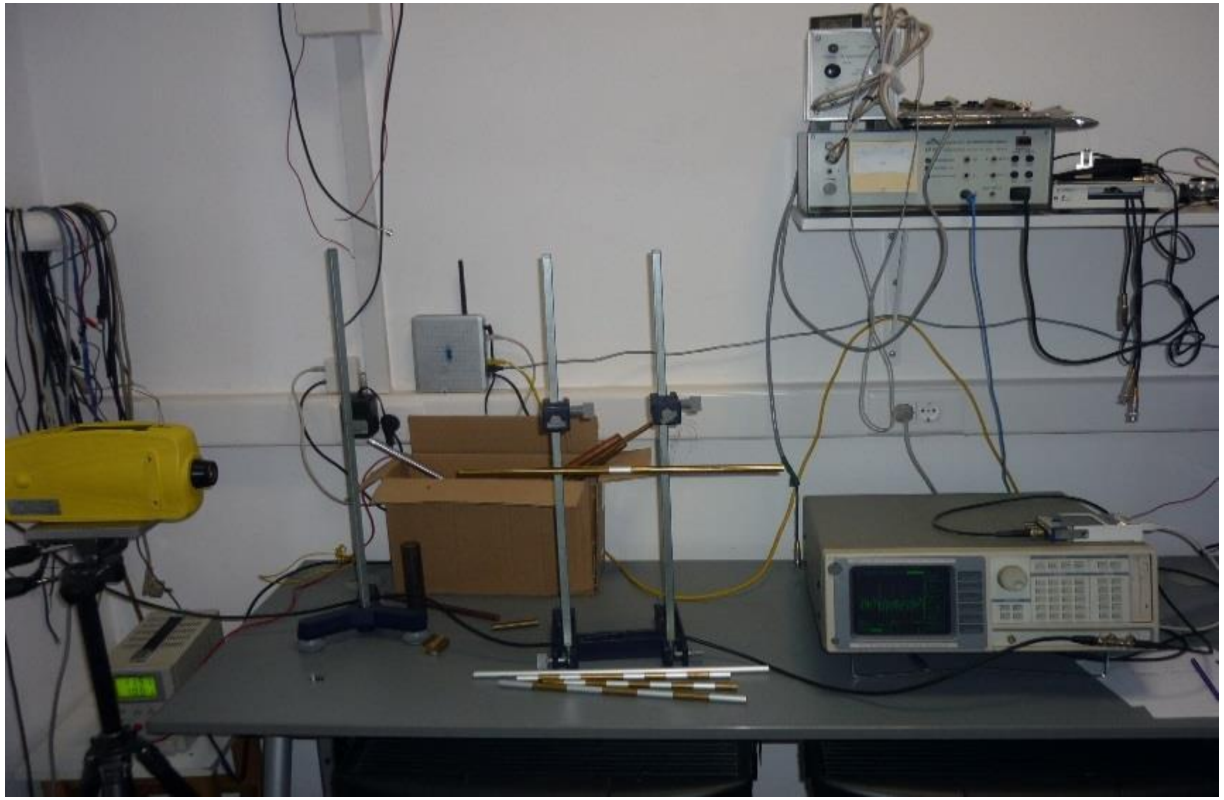


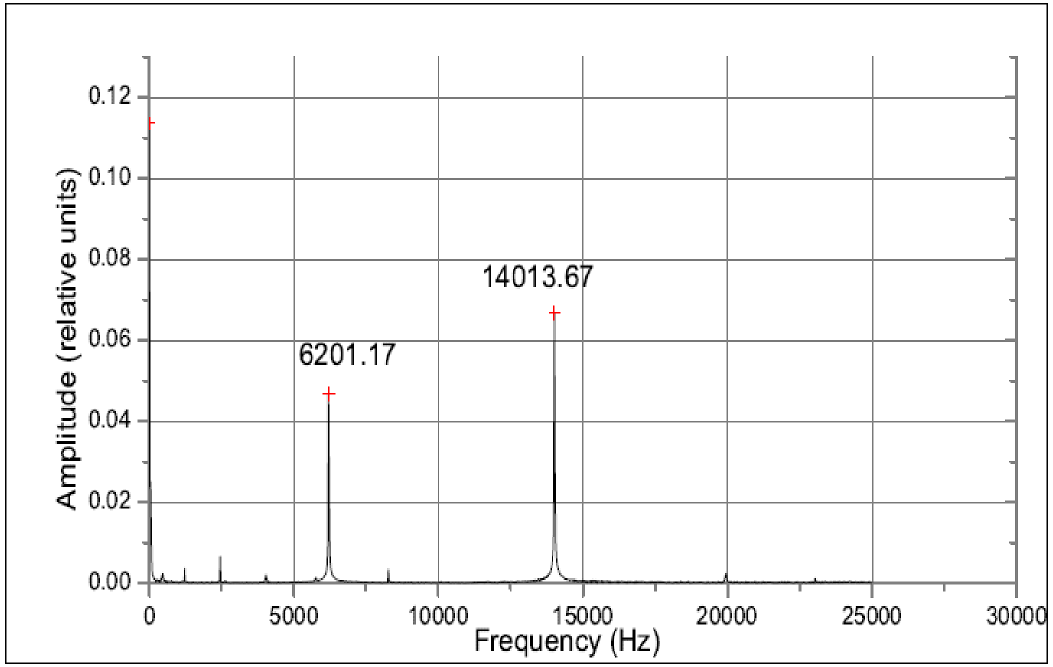
Influenta dispersiei in materialul etalon pentru sistemul ternar alama-aluminiu alama. Ca material etalon a fost considerata alama.



Influenta atenuarii in materialul cercetat pentru sistemul ternar alama-aluminiu-alama. Factorul de atenuare este considerat cel din materialul de cercetat.

Instalatia de măsurare





Extinderi ale formalismului matricii de transfer- utilizarea în algoritmi de optimizare a structurilor acustice

Algoritmul SIMULATED ANNEALING

Numele algoritmului provine de la metoda calirii metalelor, operatie care presupune pasi mici de modificare a temperaturii si apoi mentinerea probei un timp indelungat in vecinatatea temperaturii corespunzatoare tranzitiei de faza. Sistemul studiat ajunge intr-o stre de echilibru care corespunde unei stari de energie totala minima

$$\{r_i\},\{r_j\}\ldots \qquad P\{r_i\} = exp\{-E\{r_i\}/kT\}$$

Algoritmul Simulated Annealing

Cazul $\Delta E < 0$

In cazul in care pentru dua stari consecutive Satisfac aceasta conditie, noua configuratie sete acceptata si considerate ca stare initala pentru noua iteratie

Cazul $\Delta E > 0$

- Abordare probabilista
- Se calculeaza

$$P(\Delta E) = exp\{-\Delta E / kT\}$$

- Se compara probabilitatea cu un numar aleator uniform ditribuit intre (0,1)
- Daca probabilitatea P(ΔE) este mai mare decat numarul aleator atunci configuratia este acceptata, daca nu configuratia initiala este utilizata pentru un nou pas iterativ

Problema comis voiajorului: $$f(i) = \sum_i \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2}$$

$$T = D_{n,out} P_n D_{n-1,n} P_{n-1} D_{n-2,n-1} \ldots P_2 D_{2,1} P_1 D_{in,1} = D_{n,out} \left[\prod_{j=0}^{n-1} P_{n-j} D_{n-j-1,n-j} \right] D_{in,1}$$

$$A_{in}(\omega) = \frac{1}{\sqrt{2\pi}} \int_0^{+\infty} u_{injected}(0,t) \exp(i\omega t) dt,$$

$$B_{in}(\omega) = \frac{1}{\sqrt{2\pi}} \int_0^{+\infty} u_{reflected}(0,t) \exp(i\omega t) dt,$$

$$A_{out}(\omega) = \frac{1}{\sqrt{2\pi}} \int_0^{+\infty} u_{transferred}(L,t) \exp(i\omega t) dt,$$

$$B_{out}(\omega) = \frac{1}{\sqrt{2\pi}} \int_0^{+\infty} u_{reflected}(L,t) \exp(i\omega t) dt.$$

$$F^*(\omega) = A_{out}(\omega) / A_{in}(\omega)$$

$$C = \sum_{k=1}^{N} \left[F(\omega_k) - \left| A_{out}(\omega_k) \right| \right]^2$$

$$\Delta C_i = \tilde{C}_i - C_{i-1}$$

$$P_i = \begin{cases} 1, \Delta C_i < 0 \\ \exp\left(-\frac{\Delta C_i}{T_i} \right), \Delta C_i \geq 0 \end{cases}$$

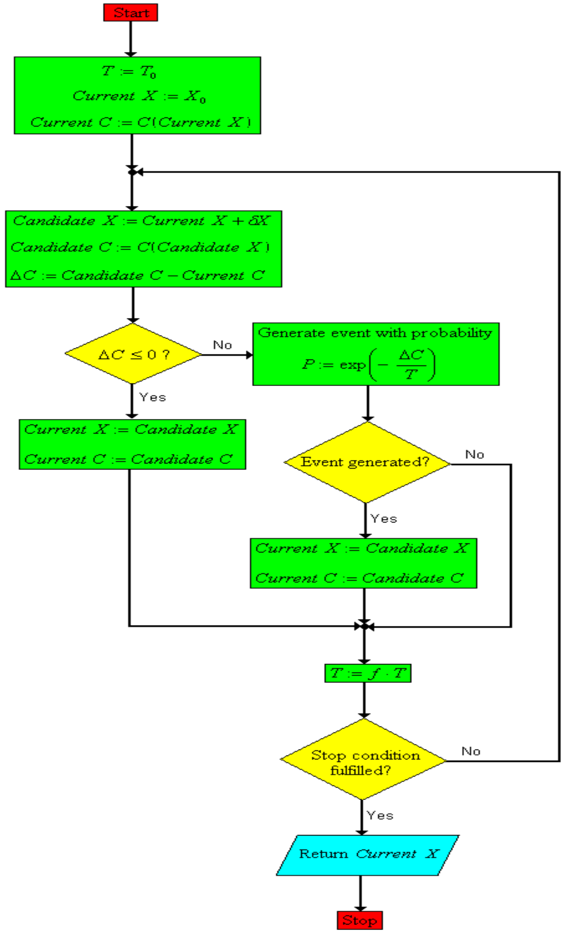
Cretu N, Pop I M, Acoustic behavior design with simulated anealing, Computational Materials Science, 44(4), 2009,1312-1318
Rosca I, Chiriacescu S. T, **Cretu N**, Utrasonic horns optimization , Physics Procedia, 3 (1) 2010, 1033-1040
Cretu N, Pop M I, Rosca I, Acoustic design by simulated annealing algorithm, Physics Procedia, 3 (1),2010, 489-495
I. C.Rosca, Mihail-Ioan Pop, **Nicolae Cretu**, Experimental and numerical study on an ultrasonic horn with shape designed with an optimiuzation algorithm, Applied Acoustics, 95 , 2015, 60-69

Schema logica a algoritmului

$$X = X(Z_i, a_i, c_i)$$

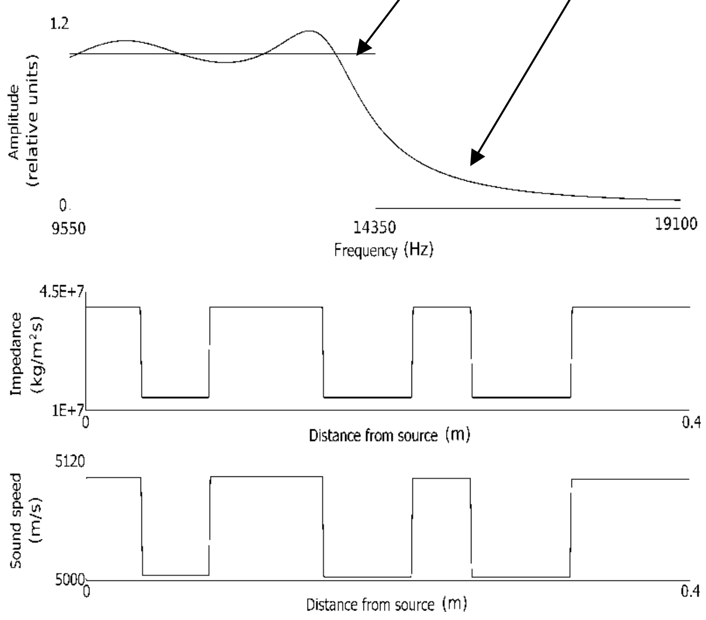
$$C(X) = \sum_{k=1}^{N} \left[F(f_k) - \left| A_{out}(f_k) \right| \right]^2$$

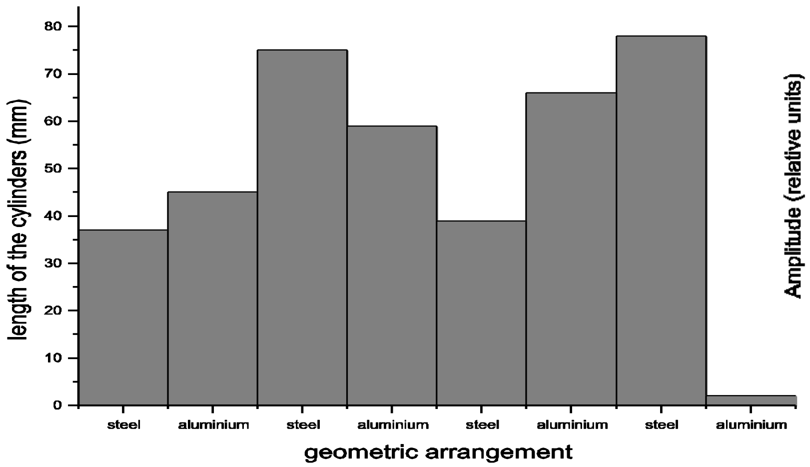
$$\begin{cases} X = (Z_i, a_i, c_i)_{i=1,2,\dots,n} = ? \\ C(X) = \sum_{k=1}^{N} \left[F(f_k) - \left| A_{out}(f_k) \right| \right]^2 = min \end{cases}$$



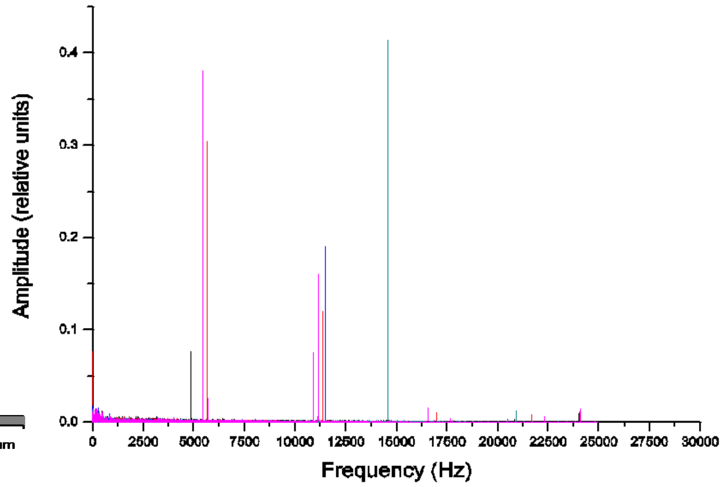
Design experimental: filtru trece jos , frecventa de taiere 14350 Hz

- Caracteristica prescrisa
- Caracteristica obtinuta prin optimizare





Multistrat otel-aluminiu



Fourier experimental bara omogena, bara multistrat

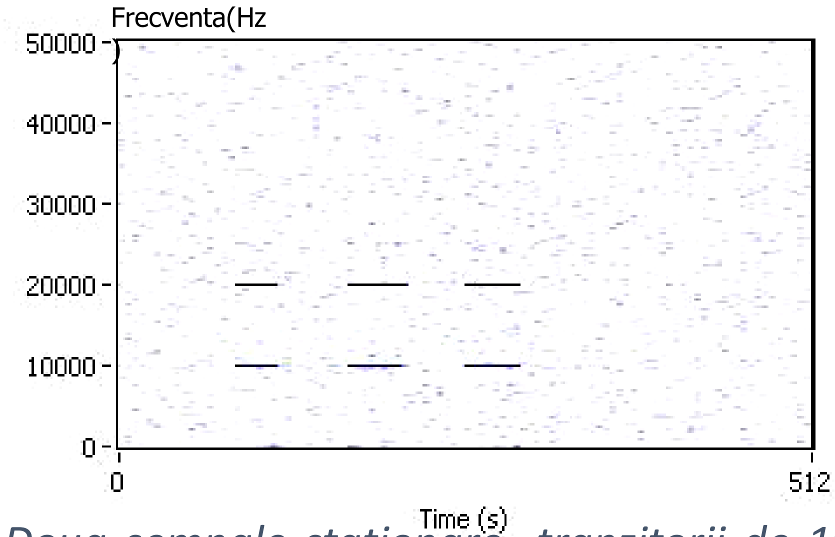
Cretu, N., Pop, I.M.-Higher order statistics in signal processing and nanometric size analysis, Journal of Optoelectronics and Advanced Materials, 10 (12), pp. 3292-3299
Cretu N, Some considerations on the magnetoacoustic effect of ferromagnetic elastic carbon steel rods, Proceedings IVth International Workshop of NDT Experts, Prague, 2007, ISBN978-80-214-3505-6, pag.43-51
N. Cretu, G. Nita, A. Boer, Acoustic behaviour of finite ferromagnetic samples, Proceedings of Intenational Congress on Ultrasonics, Viena, April 9-13, Session R21, doi:10.3728/ICUltrasonics.2007.Vienna.1032_cretu

Contributii la prelucrarea semnalelor prin folosirea momentelor statistice de ordin superior

simulare analiza

$$Kurt(x)=\frac{\mu_4}{\sigma^4}=\frac{\left\langle\left(x-\langle x\rangle\right)^4\right\rangle}{\left(\sqrt{\left\langle\left(x-\langle x\rangle\right)^2\right\rangle}\right)^4}=\frac{\int_{-\infty}^{+\infty}\left(x-\langle x\rangle\right)^4\cdot f(x)\cdot dx}{\left(\int_{-\infty}^{+\infty}\left(x-\langle x\rangle\right)^2\cdot f(x)\cdot dx\right)^2}$$

Kurtosis spectral- analiza statistica a amplitudinilor componentelor spectrale sau puterilor spectrale

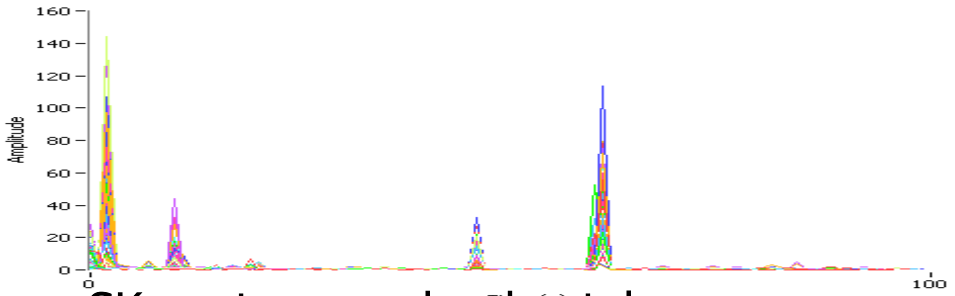


Doua semnale stationare tranzitorii de 10KHz si 20 KHz care apar la trei momente diferite de timp si durata acestora- reprezentare obtinua prin SK.

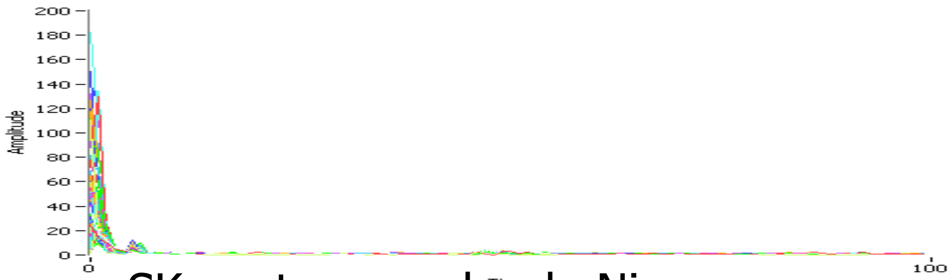
Cretu N, Nita G, Boer A, ΔE Effect for poly cristalline ferromagnetic rods, IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control, 55(2), 2008, 415-420

Cretu N, Nita G, Transfer coefficient of magnetoelastic materials, UPB Sci. Bulletin Series A, 67(4),2005, 193-202

K si SK utilizate in NDE



SK pentru o proba de otel



SK pentru o proba de Ni

N. Cretu, M.I. Pop, Acoustic behavior design with simulated annealing, *Computational Materials Science* 44(4) (2009) 1312-1318.
N. Cretu, I.C. Rosca, M.I. Pop, Eigenvalues and eigenvectors of the transfer matrix, *International Congress on Ultrasonics, Gdańsk (2011), AIP Conference Proceedings 1433(1) (2012) 535-538.*
N. Cretu, G. Nita, A simplified modal analysis based on the properties of the transfer matrix, *Mechanics of Materials* 60 (2013) 121-128.
N. Cretu, M.I. Pop, A. Boer, Quaternion formalism for the intrinsic transfer matrix, *International Congress on Ultrasonics, Metz (2015), Physics Procedia (in press).*
M. Özdemir, A.A. Ergin, Rotations with unit timelike quaternions in Minkowski 3-space, *Journal of Geometry and Physics* 56 (2006) 322-336.

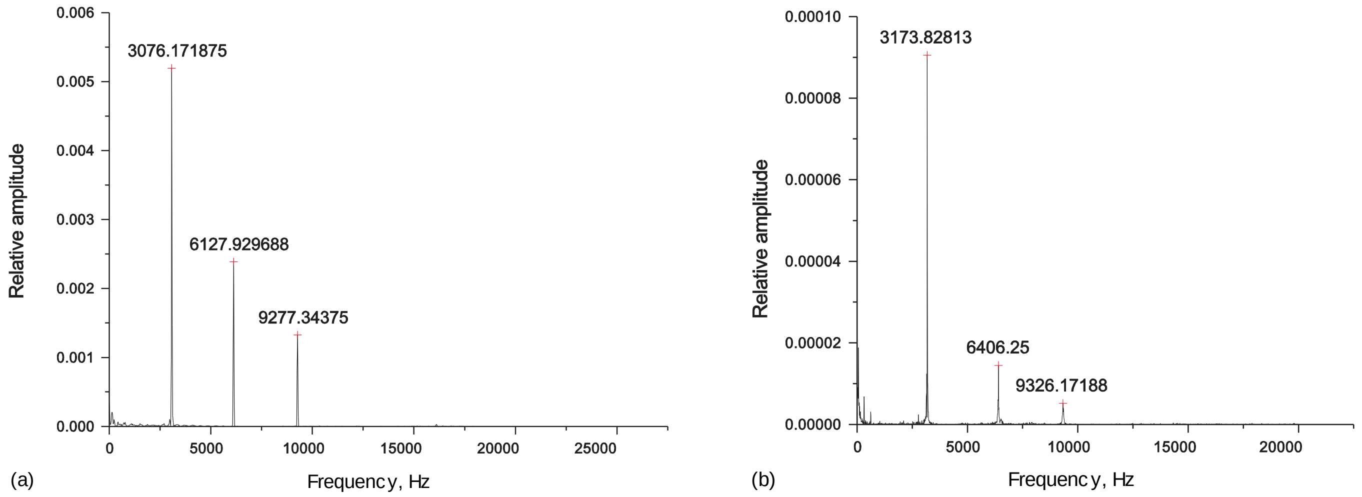
Cercetari asupra comportarii cristalelor sonice . Formalismul split-cuaternionic.

$$q = s + xi + yj + zk$$

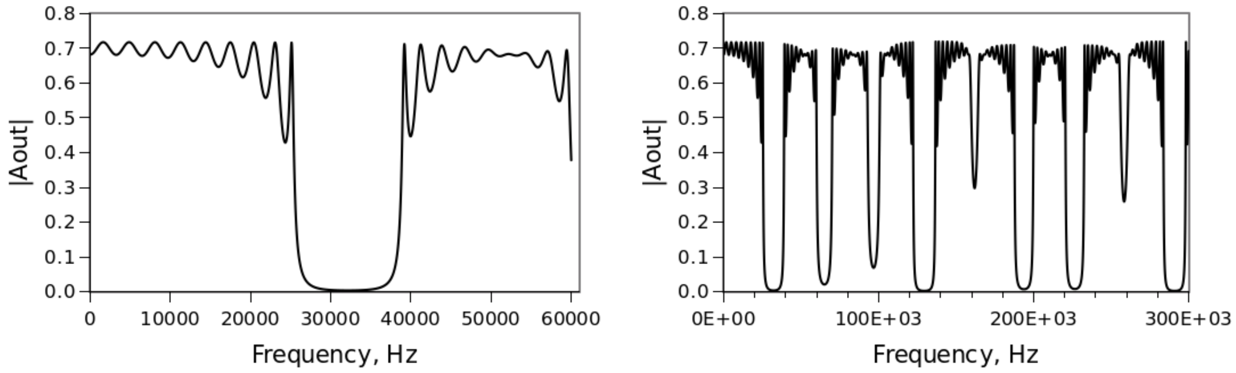
$$T_q = \begin{pmatrix} Tm\, q & Sp\, q \\ (Sp\, q)^* & (Tm\, q)^* \end{pmatrix}$$

$$Tm\, q = s + xi$$

$$Sp\, q = y + zi$$



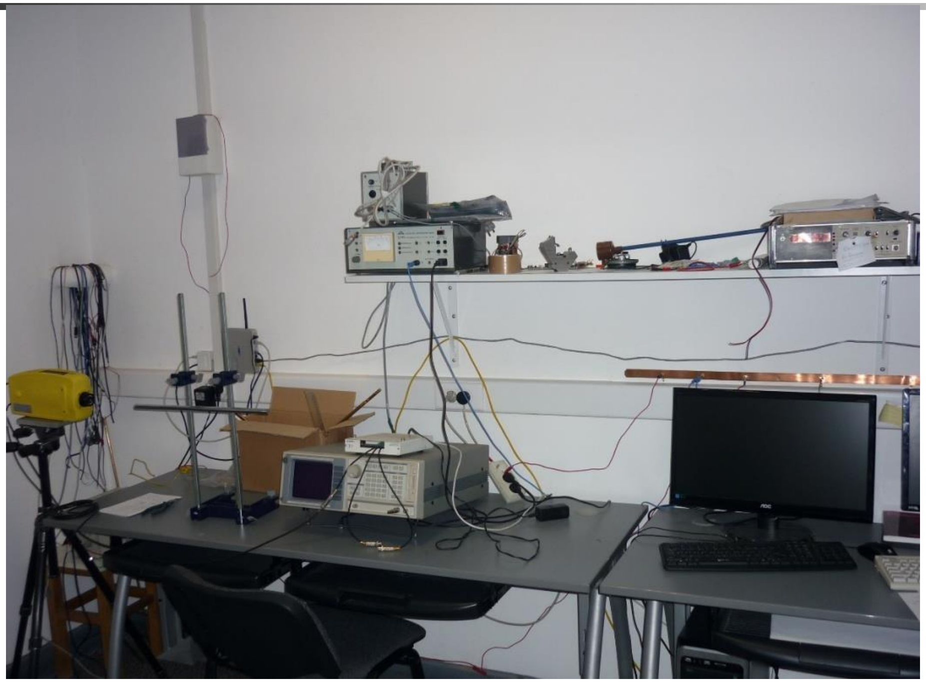
Frecvențele proprii mășurate pentru:: (a) un sistem periodic constând din 10 perechi de sisteme binare; (b) acelasi sistem în care s-a creat o inversie (defect) între 2 straturi ale sistemului binar.



Spectrul simulat pe calculator folosind formalismul cuaternionic pentru sistemul periodic format din 10 elemente binare fara defect.

Contribuţii la dotare şi achiziţionare aparatură de cercetare. Coordonare Laboratoare de cercetare

Echipamente de microunde in banda X



Echipament pentru studiul proprieatilor elastice ale materialelor solide

Echipament pentru măsurarea rezistivităţilor electrice prin metoda celor 4 sonde

Sistemul criogenic pana la 2.5 K pentru studiul proprietătilor magnetice, conductivitatilor electrice si termice ale materialelor

Tubul acustic Bruel&Kjaer

Vibration and Acoustics; Studies from Transilvania University Further Understanding of Vibration and Acoustics

Technology & Business Journal (Sep 10, 2013): 1395.

Abstract (summary) Translate

According to the news editors, the research concluded: "We conclude that the proposed experimental method may be reliably used to determine the elastic properties of small solid samples whose geometries do not allow a direct measurement of their resonant frequencies."

Full Text Translate

2013 SEP 10 (VerticalNews) -- By a News Reporter-Staff News Editor at Technology Business Journal -- Investigators discuss new findings in Vibration and Acoustics. According to news reporting out of Brasov, Romania, by VerticalNews editors, research stated, "An experimental method for determining the phase velocity in small solid samples is proposed. The method is based on measuring the resonant frequencies of a binary or ternary solid elastic system comprising the small sample of interest and a gauge material of manageable size."

Our news journalists obtained a quote from the research from Transilvania University, "The wave transmission matrix of the combined system is derived and the theoretical values of its eigenvalues are used to determine the expected eigenfrequencies that, equated with the measured values, allow for the numerical estimation of the phase velocities in both materials. The known phase velocity of the gauge material is then used to asses the accuracy of the method. Using computer simulation and the experimental values for phase velocities, the theoretical values for the eigenfrequencies of the eigenmodes of the embedded elastic system are obtained, to validate the method."

According to the news editors, the research concluded: "We conclude that the proposed experimental method may be reliably used to determine the elastic properties of small solid samples whose geometries do not allow a direct measurement of their resonant frequencies."

For more information on this research see: Wave transmission approach based on modal analysis for embedded mechanical systems. Journal of Sound and Vibration, 2013;332(20):4940-4947. Journal of Sound and Vibration can be contacted at: Academic Press Ltd- Elsevier Science Ltd, 24-28 Oval Rd, London NW1 7DX, England. (Elsevier - www.elsevier.com; Journal of Sound and Vibration - www.elsevier.com/wps/product /cws_home/622899)

Our news journalists report that additional information may be obtained by contacting N. Cretu, Transilvania

Fluxmetru magnetic FIM02

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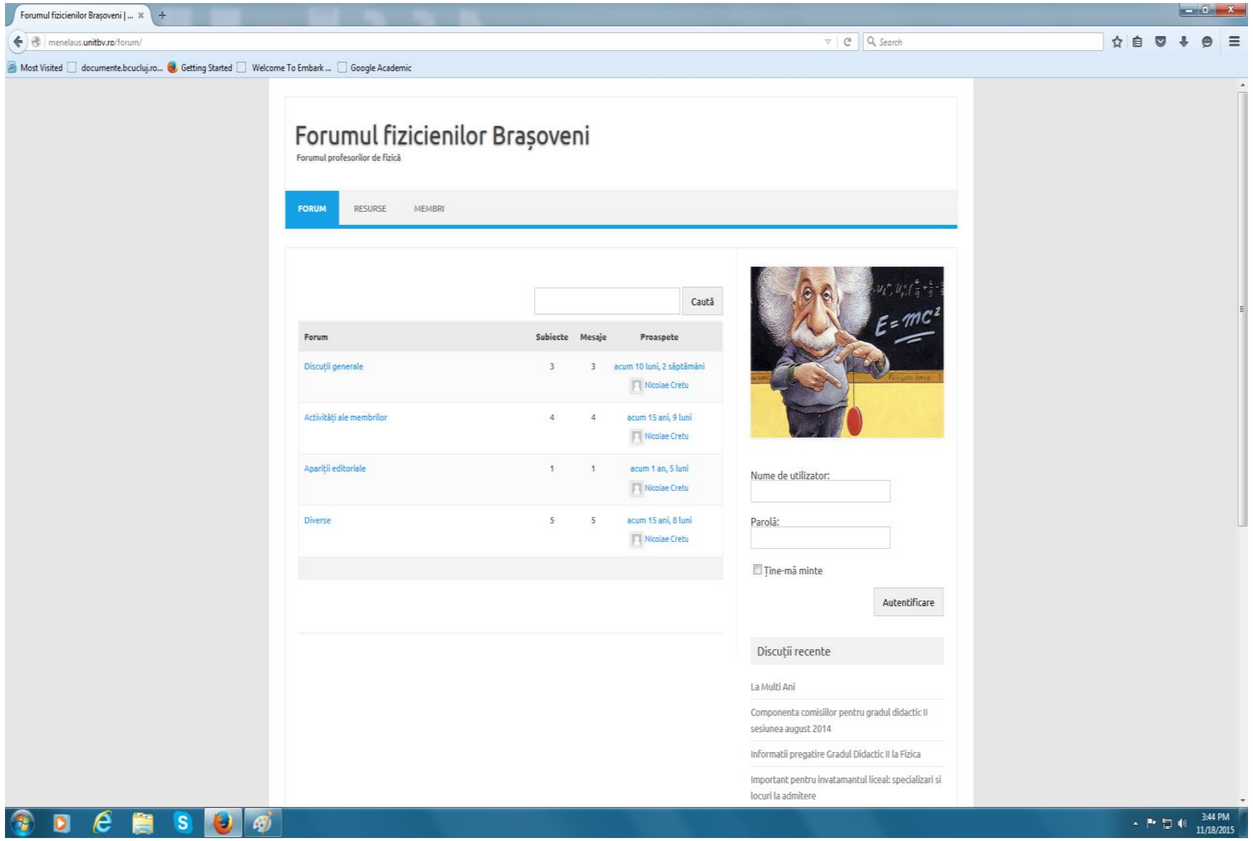

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