С. Торайғыров атындағы Павлодар мемлекеттік университетінің ғылыми журналы
Научный журнал Павлодарского государственного университета им. С. Торайгырова

1997 жылы құрылған
Основан в 1997 г.

Ï Ì Ó
ÕÀÁÀÐ Ø ÛÑÛ

ÂÅÑÒ Í ÈÊ Ï ÃÓ

ФИЗИКО - МАТЕМАТИЧЕСКАЯ СЕРИЯ

2 2014

Научный журнал Павлодарского государственного университета
имени С. Торайгырова

СВИДЕТЕЛЬСТВО
о постановке на учет средства массовой информации
№ 14213-Ж
выдано Министерством культуры, информации и общественного согласия
Республики Казахстан
04 марта 2014 года

МАЗМҰНЫ

UDC 51

N. A. Ispulov[1], A. K. Seythanova[2], T. G. Kissikov[3]

[1]candidate of physical-mathematical sciences, associate professor, dean of the physics, matematics and IT faculty, S. Toraighyrov Pavlodar State University; [2]candidate of physical-mathematical sciences, Innovative University of Eurasia, Pavlodar; [3]graduate student, UC Davis, University of California, USA

REFLECTION OF THERMOELASTIC WAVE ON THE BORDER OF ISOTROPIC HALF-SPACE AND ANISOTROPIC MEDIUM WITH THERMOMECHANICAL EFFECT

Analysis for the thermoelastic wave propagation in a tetragonal syngony anisotropic medium of classes 4, $\overline{4}$*, 4/m having heterogeneity along Z axis is investigated in the contexed of matrizant method. For this medium presence of second order axis symmetry for which Z axis is parallel is typical. For the case of 4th order matrix coefficients problems of wave refraction and reflection on the border of homogeneous anisotropic thermoelastic mediums were solved analytically.*

Keywords: Anisotropic medium, thermoelasticity, Fourier heat equation, harmonic waves, dispersion, periodic structure, matriciant.

I. Introduction

The coupling between thermal and mechanical fields in solid bodies gives rise to the dynamic theory of thermoelasticity. The theory has many applications in various engineering fields for instance, earthquake engineering, soil mechanics, aeronautics, nuclear engineering, ets. It is well known that the classical theory of thermoelasticity [1,2] rests upon the hypothesis of the Fourier law of heat conduction, in which the temperature distribution is governed by a parabolic-type partial differential equation. The theory predicts that a thermal signal is felt instantaneously everywhere in a body. This is unrealistic from the physical point of view, especially for short-time responses. To account for the effect of thermal relaxation, generalized thermoelasticity has been formulated on the basis of a modified Fourier law, such that the temperature distribution is governed by a hyperbolic-type equation. Accordingly, heat transfer in solids is regarded as a wave phenomenon rather than a diffusion phenomenon.

The investigation of wave propagation in anisotropic medium with various physical and mechanical properties has been carried out with the matricant method [3,4,5].

The application of matricants method for non-destructive testing and wave propagation in thermo elastic media is considered [6]. In the paper [7], waves propagating along an arbitrary direction in a heat conducting orthotropic thermoelastic plate are presented by utilizing the normal mode expansion method in generalized theory of thermo elasticity with one thermal relaxation time. In the paper [8], authors studied the interaction of free harmonic waves with multilayered media in generalized thermo elasticity by utilizing the combination of the linear transformation formation and transfer matrix method approach.

In this paper, we have investigated the wave propagation in anisotropic inhomogeneous medium. A new method of matricant has been developed. The structure of matricant for the equation of motion, equations in elastic and equations of thermo-mechanical medium has been established. Wave propagation in infinite and finite periodical inhomogeneous media are studied. Solutions obtained are general and pertain to several special cases. Of these mention: (a) dispersion characteristics for a multilayered.

II. Problem and basic relations

Propagation of thermo elastic waves in anisotropic media is based on the simultaneous solution of equations of motion, the Fourier heat equation and the equation of heat, which have the form [2]:

$$\sigma_{ij,j} = \rho \ddot{U}_i \qquad (1)$$

$$\lambda_{ij} \frac{\partial \theta}{\partial x_j} = -q_i \qquad (2)$$

$$\frac{\partial q_i}{\partial x_i} = -i\omega \beta_{ij} \varepsilon_{ij} - i\omega \frac{c_\varepsilon}{T_0} \theta \qquad (3)$$

where σ_{ij} – stress tensor, ρ – density of medium, λ_{ij} – thermal conductivity tensor, q_i – vector of heat gain, ω – circular frequency, β_{ij} – thermomechanical parameters of medium, ε_{ij} – tensor of small Cauchy deformation, $\tilde{n}_\varepsilon$ – heat capacity under constant deformation, θ=T-T_0 – temperature increase compared with the temperature of the natural state T_0, $\left|\frac{\theta}{Ò_0}\right| \prec 1$ for small deformations.

Physical and mechanical quantities are related by Duhamel-Neumann:

$$\sigma_{ij} = c_{ijkl}\varepsilon_{kl} - \beta_{ij}\theta \qquad (4)$$

Equations (1) – (4) determine the relationship of mechanical stress and temperature as a function of the independent variables - the thermal field and deformation.

Based on the method of separation of variables, equation (1), (2), (3), (4) are reduced to a system of ordinary differential equations (medium heterogeneity is assumed along the Z axis, axis z$\parallel \grave{A}_2$):

$$\frac{d\vec{W}}{dx} = B\vec{W} \qquad (5)$$

Where

$$\vec{W}(x,y,z,t) = \left[u_z(z)\ \sigma_z\ ,u_x(z)\ \sigma_x\ ,u_y(z)\ \sigma_y\ ,q_z,\theta\right]^t \exp(i\omega t - imx - iny) \qquad (6)$$

– column vector of the boundary conditions; while

$$B = B\left[c_{ijkl}(z)\ \beta_j(z)\ \theta,\omega,m,n,l\right] \qquad (7)$$

– coefficient matrix whose elements contain the parameters of the medium in which thermoelastic waves propagate; m, n, l - the components of the wave vector.

In this paper, the analysis of the coefficient matrix allowed us to determine the polarization of the waves and their relationship spreading with the influence of the thermomechanical effect.

III. Formulation of the problem

Let's consider the problem of thermoelastic wave reflection at the interface between isotropic and anisotropic half-space environment tetragonal syngony classes 4, 4/m with the thermomechanical effect. Because of the thermo-mechanical effects in a thermoelastic medium bound thermoelastic waves propagate.

Let the interface is z = 0 plane. We orient anisotropic medium in such way so that the axis of a Cartesian coordinate system coincide with the corresponding crystallographic axes. Let on the interface of an isotropic medium heat wave falls, that is, the heat flux vector lies in the plane of incidence. The plane of incidence is the plane containing the normal drawn to the interface and the wave vector.

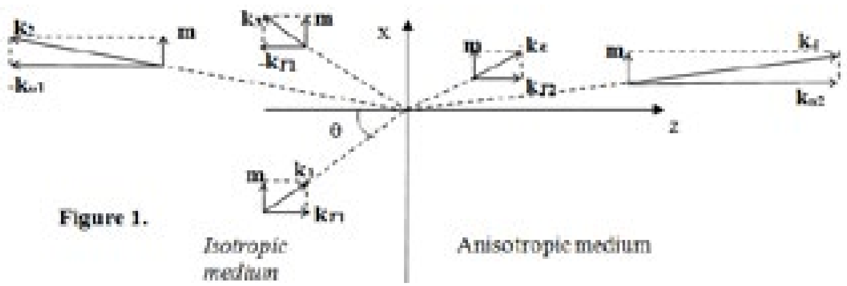

Figure 1.

In this case, the incident thermal wave in an anisotropic medium is related to the elastic longitudinal wave of z polarization, and a system of first order differential equations (5) can be written as:

$$\begin{cases} \dfrac{dU_z}{dZ} = \dfrac{1}{c_{33}}\sigma_{zz} + \dfrac{2\beta_{11}+\beta_{33}}{c_{33}}\theta \\ \dfrac{d\sigma_{zz}}{dZ} = -\rho\omega^2 U_z \\ \dfrac{d\theta}{dz} = -\dfrac{1}{\lambda_{33}}q_z \\ \dfrac{dq_z}{dZ} = -i\omega\dfrac{2\beta_{11}+\beta_{33}}{c_{33}}\sigma_{zz} - i\omega\left(\dfrac{c_e}{\grave{O}_0} + \dfrac{\beta_{33}^2}{c_{33}}\right)\theta, \end{cases} \qquad (8)$$

System (8) as it was above can be written in matrix form:

$$\frac{d\vec{w}}{dz} = B_2\vec{w} \qquad (9)$$

where $\vec{w} = (u_z, \sigma_{zz}, \theta, q_z)^t$

$$B_2 = \begin{pmatrix} 0 & b_{12} & b_{17} & 0 \\ b_{21} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{78} \\ 0 & -i\omega b_{17} & b_{87} & 0 \end{pmatrix} \qquad (10)$$

The index «2» in front of the coefficient matrix indicates the second medium; components of the matrix of coefficients (10) have the form:

$$b_{12} = \frac{1}{c_{33}},\quad b_{17} = \frac{(2\beta_{11}+\beta_{33})}{c_{33}},\quad b_{21} = -\omega^2\rho,$$

$$b_{87} = -i\omega\left(\frac{\beta_{33}^2}{c_{11}} + \frac{c_e}{T_0}\right),\quad b_{78} = -\frac{1}{\lambda_{33}}.$$

Let's write matricant of the second medium (direct wave):

$$T_2^+(0) = \frac{1}{2}(E + i\alpha R_2) \qquad (11)$$

α is given by:

$$\alpha = \frac{1}{k_{\grave{O}2}k_{u2}(k_{\grave{O}2}+k_{u2})} \qquad (12)$$

Indices of «T» and «u2» mean z-components of the wave vector in the second medium.

For matrix coefficients from (10)

$$k_{u2} = \sqrt{\frac{1}{2}\left(-b_{12}b_{21} - b_{78}b_{87} - (b_{12}b_{21} - b_{78}b_{87})\sqrt{1 - \frac{4i\omega b_{17}^2 b_{21} b_{78}}{(b_{12}b_{21} - b_{78}b_{87})^2}}\right)} \quad (13)$$

$$k_{T2} = \sqrt{\frac{1}{2}\left(-b_{12}b_{21} - b_{78}b_{87} + (b_{12}b_{21} - b_{78}b_{87})\sqrt{1 - \frac{4i\omega b_{17}^2 b_{21} b_{78}}{(b_{12}b_{21} - b_{78}b_{87})^2}}\right)} \quad (14)$$

We introduce the notations:

$$a = -b_{12}b_{21} - b_{78}b_{87} \quad (15)$$

$$\Delta = (b_{12}b_{21} - b_{78}b_{87})\sqrt{1 - \frac{4i\omega b_{17}^2 b_{21} b_{78}}{(b_{12}b_{21} - b_{78}b_{87})^2}} \quad (16)$$

We introduce the matrix R_2 for the matrix coefficients (10), as a result we obtain:

$$R_2 = \begin{pmatrix} 0 & r_{12} & r_{13} & 0 \\ r_{21} & 0 & 0 & r_{24} \\ -i\omega r_{24} & 0 & 0 & r_{34} \\ 0 & -i\omega r_{13} & r_{43} & 0 \end{pmatrix} \quad (17)$$

where $r_{12} = -b_{78}(i\omega b_{17}^2 + b_{12}b_{87}) - b_{12}\sqrt{b_{21}b_{78}(i\omega b_{17}^2 + b_{12}b_{87})}$;

$$r_{13} = b_{17}\sqrt{b_{21}b_{78}(i\omega b_{17}^2 + b_{12}b_{87})};$$

$$r_{21} = -b_{21}b_{78}b_{87} + b_{21}\sqrt{d_{21}b_{78}(i\omega b_{17}^2 + b_{12}b_{87})};\quad r_{24} = b_{17}b_{21}b_{78};$$

$$r_{34} = -b_{12}b_{21}b_{78} + b_{78}\sqrt{b_{21}b_{78}(i\omega b_{17}^2 + b_{12}b_{87})};$$

As in an isotropic medium incident heat wave is not related to the elastic, so that the structure of the coefficient matrix in this case takes the form:

$$B_1 = \begin{pmatrix} 0 & b_{12} & 0 & 0 \\ b_{21} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{78} \\ 0 & 0 & b_{87} & 0 \end{pmatrix} \quad (18)$$

The index “1” in front of the coefficient matrix means the first medium:

$$b_{12} = \frac{2}{c_{11} - c_{12}};\ b_{21} = -\rho_1\omega^2 + \frac{m^2(c_{11} - c_{12})}{2};\ b_{78} = -\frac{1}{\lambda_{11}};\ b_{87} = -\frac{i\omega c_\varepsilon}{T_0}.$$

As seen from (18), the coefficient matrix is divided into two matrices of second order, so matriciant of the first environment can be written by using

$$T_{ycp}^{\pm} = \frac{1}{2}(E \mp \frac{\langle B \rangle}{ik})e^{\mp ikz} \quad (19)$$

As a result, we obtain

$$T_1^{\pm} = \begin{pmatrix} 1 & \pm\frac{ib_{12}}{k_{u1}} & 0 & 0 \\ \pm\frac{ib_{21}}{k_{u1}} & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}\frac{e^{\mp ik_{u1}z}}{2} + \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & \pm\frac{ib_{78}}{k_{T1}} \\ 0 & 0 & \pm\frac{ib_{87}}{k_{T1}} & 1 \end{pmatrix}\frac{e^{\mp ik_{T1}z}}{2} \quad (20)$$

where k_{u1} and k_{T1} – z-components of the first medium’s wave vectors.

$$k_{u1} = \sqrt{-b_{12}b_{21}};\ k_{T1} = \sqrt{-b_{78}b_{87}} \quad (21)$$

Substituting in the definition of the matrix G matricant of the second medium at z = 0 (11), with the structure of the matrix (17), and matricant of the first medium at z = 0 (20), we obtain the matrix

$$G = \begin{pmatrix} g_{11} & 0 & 0 & g_{14} \\ 0 & g_{22} & g_{23} & 0 \\ 0 & g_{32} & g_{33} & 0 \\ g_{41} & 0 & 0 & g_{44} \end{pmatrix} \quad (22)$$

with elements

$$g_{11} = -1 + \frac{2b_{21}(b_{78} + k_{\acute{o}1}r_{34}\alpha)}{\Delta_1};\ g_{14} = -\frac{2b_{78}k_{u1}r_{24}\alpha}{\Delta_1};$$

$$g_{22} = -1 + \frac{2b_{12}(b_{87} + k_{\acute{o}1}r_{43}\alpha)}{\Delta_2};\ g_{23} = -\frac{2b_{87}k_{u1}r_{13}\alpha}{\Delta_2};\ g_{32} = \frac{2i\omega b_{12}k_{\acute{o}1}r_{13}\alpha}{\Delta_2};$$

$$g_{33} = -1 + \frac{2b_{87}(b_{12} + k_{u1}r_{12}\alpha)}{\Delta_2};\ g_{41} = \frac{2i\omega b_{21}k_{\acute{o}1}r_{24}\alpha}{\Delta_1};$$

$$g_{44} = -1 + \frac{2b_{78}(b_{21} + k_{u1}r_{21}\alpha)}{\Delta_1};$$

Vector of the incident wave amplitude can be written as:

$$\vec{w}_0 = (0,0,\theta_0,q_0)^t \qquad (23)$$

Condition (23) relates the amplitude of the temperature increment θ_0 and heat flux q_0 of fields of the incident heat wave

$$\theta_0 = \frac{ib_{78}}{k_{T1}}q_0 \text{ или } \theta_0 = \frac{k_{T1}}{ib_{87}}q_0 \qquad (24)$$

The expression for the matrix G (22), the vector of the incident wave amplitude (23) allow us to write the vector of amplitudes of reflected and refracted waves:

$$\begin{cases} u_r = g_{14}q_0 \\ \sigma_r = g_{23}\theta_0 \\ \theta_r = g_{33}\theta_0 \\ q_r = g_{44}q_0 \end{cases} \qquad (25)$$

$$\begin{cases} u_t = g_{14}q_0 \\ \sigma_t = g_{23}\theta_0 \\ \theta_t = (1+g_{33})\theta_0 \\ q_t = (1+g_{44})q_0 \end{cases} \qquad (26)$$

From the expression for the vectors of amplitudes of reflected and refracted waves (25) and (26) it can be seen that due to the fall of the heat wave $u_r = u_t$ and $\sigma_r = \sigma_t$.

Conditions (19) and (20):

$$\vec{w}_{refl}(0) = T_1^-(0)\vec{w}_r = \vec{w}_r \qquad (27)$$

$$\vec{w}_{refr}(0) = T_2^+(0)\vec{w}_t = \vec{w}_t \qquad (28)$$

relate the amplitude of the displacement and stress and the amplitude of temperature and heat flux of reflected and refracted waves:

$$\sigma_r = -\frac{k_{u1}}{\ldots}u_r \text{ or } \sigma_r = -\frac{ib_{21}}{\ldots}u_r \qquad (29)$$

$$\theta_r = -\frac{ib_{\cdot}}{k_{T1}}q_r \text{ or } q_r = -\frac{k_{T1}}{ib_{87}}q_r \qquad (30)$$

$$\begin{cases} u_t = i\alpha(r_{12}\sigma_t + r_{13}\theta_t) \\ \sigma_t = i\alpha(r_{21}u_t + r_{24}q_t) \\ \theta_t = i\alpha(-i\omega r_{34}u_t + r_{34}q_t) \\ q_t = i\alpha(-i\omega r_{13}\sigma_t + r_{43}\theta_t) \end{cases} \qquad (31)$$

The expressions for the incident wave $\vec{w}_{inc} = T_1^+\vec{w}_0$ and $\vec{w}_{refl} = T_1^-\vec{w}_r$ for the field of reflected wave, matriciant of the first medium (19) and matrix (20) allow us to write in an explicit form field of the incident heat and reflected elastic and thermal waves:

$$\begin{cases} \theta_z^{inc} = \theta_0 e^{-k_{T1}z} \\ q_z^{inc} = q_0 e^{-k_{T1}z} \end{cases} \qquad (32)$$

$$\begin{cases} u_z^{refl} = g_{14}q_0 e^{ik_{u1}z} \\ \sigma_{zz}^{refl} = g_{23}\theta_0 e^{ik_{u1}z} \\ \theta_z^{refl} = g_{33}\theta_0 e^{ik_{T1}z} \\ q_z^{refl} = g_{44}q_0 e^{ik_{T1}z} \end{cases} \qquad (33)$$

In the system (8), z component of the heat flux, (32) and (33) allow us to calculate the energy fluxes of the reflected elastic and thermal waves.

The flow of heat energy is given by

$$q_{\grave{o}} = \theta\vec{q} \qquad (34)$$

The flow of elastic energy is

$$P_j = -\sigma_{ij}\frac{\partial u_i}{\partial t} \qquad (35)$$

IV. Conclusion

In this paper, based on the method matriciant [5] the problem of propagation of thermoelastic waves in an anisotropic medium tetragonal syngony of classes 4, 4/m, in the case of inhomogeneity along the axis Z was considered. In this paper we analytically solved the problem of reflection and refraction at the boundary of the homogeneous anisotropic thermoelastic media, in the case of the coefficient matrices of order 4.

LIST OF REFERENCES

1 **Nowacki, W.** (1975): Dynamic Problems of Thermoelasticity. – Noordhoff, The Netherlands.

2 **Nowacki, W.** Thermoelasticity. – 2nd edition. – Pergamon Press, Oxford, 1986.

3 **Tleukenov, S.** Investigation of the thin layer influence of the boundary conditions. Abstacts «Seminar on earsquare processe and their consequences». – Kurukshetra, India, 1989. – P. 4.

4 **Tleukenov, S.** The structure of propagabor matrix and it is application in the case of the periodical inhomogeneous media. – Abstr. Semin. on Earthquake processes and their consequences. – Seismological investigations.– Kurukshetra, India, 1989. – P. 2-4.

5 **Tleukenov, S.** Matrizant method. – Pavlodar : S. Toraighyrov PSU, [In Russian], 2004. – 148 p.

6 Nondestructive testing: Reference book: 7 chapters. Edited by V.V. Kluev. – Ch. 4: In 3rd book. Book 1: Acoustic strain metering./ V. A. Anisimov, B. I. Katorgyn, A. N. Kutsenko and others. – M. : Mechanical engineering, 2004. – 736 p.: pictures.

7 **Verma, K. L.** Thermoelastic waves in anisotropic plates using normal mode expansion method with thermal relaxation time. – international Journal of Aerospace and Mechanical Engineering 2:2, 2008. – PP. 86-93.

8 **Verma, K. L.** The general problem of thermoelastic wave propagation in multilayered anisotropic media with application to periodic media, International Journal of Applied Engineering Research, Dindigul. – Volume 1, No4, 2011. – PP. 908-922.

Material received on 17.04.14.

Н. А. Испулов[1], А. К. Сейтханова[2], Т. F. Кисиков[3]

Термомеханикалық эффектісі бар анизотропты ортаның тетрагоналдық сингонияның 4, $\bar{4}$, 4/m класстарының және изотропты жартылай кеңістіктің бөлу шекарасындағы толқындардың шағылу есебі

[1]Павлодар мемлекеттік университеті, Павлодар қ.;
[2]Инновациялық Еуразия университеті, Павлодар қ.;
[3]Дэвис университеті, Калифорния, АҚШ.

Материал 17.04.14 баспаға түсті.

Н. А. Испулов[1], А. К. Сейтханова[2], Т. Г. Кисиков[3]

Задача отражения волн на границе раздела изотропного полупространства и анизотропной среды тетрагональной сингонии классов 4, $\bar{4}$, 4/m с термомеханическим эффектом

[1]Павлодарский гоударственный университет имени С. Торайгырова; г. Павлодар;
[2]Инновационный Евразийский университет, г. Павлодар;
[3]Университет Дэвиса, Калифорния, США.

Материал поступил в редакцию 17.04.14.

Мақалада Термомеханикалық эффектісі бар анизотропты ортаның тетрагоналдық сингонияның 4, $\bar{4}$, 4/m класстарының және изотропты жартылай кеңістіктің бөлу шекарасындағы толқындардың шағылу есебі қарастырылған.

В статье автор рассматривает задачу отражения волн на границе раздела изотропного полупространства и анизотропной среды тетрагональной сингонии классов 4, $\bar{4}$, 4/m с термомеханическим эффектом.

УДК 004.421

Д. С. Найманова[1], Е. С. Московченко[2]
[1]доцент, к.п.н., [2]магистрант, Павлодарский государственный университет имени С. Торайгырова, г. Павлодар

АНАЛИЗ ОСНОВНЫХ АЛГОРИТМОВ ПОИСКА ЗАИМСТВОВАНИЙ ДЛЯ ПРОВЕРКИ ПИСЬМЕННЫХ РАБОТ ОБУЧАЮЩИХСЯ

В настоящей статье автором приводится анализ основных алгоритмов поиска заимствований, позволивший подробнее познакомиться с их особенностями и выявить возможности для их применения.

Ключевые слова: алгоритм, поиск заимствований, интернет.

С появлением интернета общество столкнулось с одной серьезной проблемой – плагиатом. Попав в интернет, информация становится доступной абсолютно для всех, что затрудняет соблюдение авторских прав настоящего обладателя данной информации. В дальнейшем становится еще труднее идентифицировать первоначального автора. Существование многочисленных информационных ресурсов, предлагающих бесплатно или на коммерческой основе различные виды работ (от рефератов до

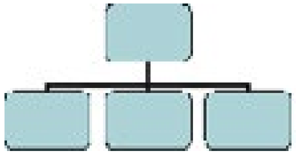
Рисунок 1 – Социальные взаимоотношения

СПИСОК ЛИТЕРАТУРЫ

1 **Эльконин, Д. Б.** Психология игры [Текст] : научное издание / Д. Б. Эльконин. – 2–е изд. – М. : Владос, 1999. – 360 с. – Библиогр. : С. 345–354. – Имен. указ. : С. 355–357. – ISBN 5-691-00256-2 (в пер.).

2 **Фришман, И.** Детский оздоровительный лагерь как воспитательная система [Текст] / И. Фришман // Народное образование. – 2006. – № 3. – С. 77–81.

3 Антология педагогической мысли Казахстана [Текст] : научное издание / сост. К. Б. Жарикбаев, сост. С. К. Калиев. – Алматы : Рауан, 1995. – 512 с. : ил. – ISBN 5625027587.

А. Б. Есімова

Отбасылық-туысты қатынастар репродуктивті мінез-құлықты жүзеге асырудағы әлеуметтік капитал ретінде

Қ. А. Ясауи атындағы Халықаралық қазақ-түрік университеті, Түркістан қ.

A. B. Yessimova

The family-related networks as social capital for realization of reproductive behaviors

K. A. Yssawi International Kazakh-Turkish University, Turkestan.

Бұл мақалада автор Қазақстандағы әйелдердің отбасылық-туыстық қатынасы арқылы репродуктивті мінез-құлқында айырмашылықтарын талдайды.

In the given article the author analyzes distinctions of reproductive behavior of married women of Kazakhstan through the prism of the kinship networks.

Теруге 09.06.2014 ж. жіберілді. Басуға 23.06.2014 ж. қол қойылды.
Форматы 70x100 1/16. Кітап-журнал қағазы.
Көлемі шартты 3,8 б.т. Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген М. А. Шрейдер
Корректорлар: З. С. Искакова, А. Елемесқызы, А. Р. Омарова
Тапсырыс № 2453

Сдано в набор 09.06.2014 г. Подписано в печать 23.06.2014 г.
Формат 70x100 1/16. Бумага книжно-журнальная.
Объем 3,8 ч.-изд. л. Тираж 300 экз. Цена договорная.
Компьютерная верстка М. А. Шрейдер
Корректоры: З. С. Искакова, А. Елемескызы, А. Р. Омарова
Заказ № 2453

«КЕРЕКУ» баспасы
С. Торайғыров атындағы
Павлодар мемлекеттік университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
67-36-69
E-mail: kereky@mail.ru