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CALCULATION OF TOMOGRAPHIC PROJECTIONS

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The article suggests a method of calculating tomographic projections.

The problem of interaction between x rays and the substance of the investigated object, arising in the field of computerized tomography, reduces to the calculation of tomographic projections [1]. The present article submits a method of calculating parallel and bundle tomographic projections for one class of images of the section of the object; the terminology and some of the designations are taken over from [1].

Let w and $\hat{w}$ be the applicates of points of the plane of the object's section in the initial system x, y and in the system of coordinates $\hat{x}$, $\hat{y}$ rotated through the angle θ, respectively, $\hat{w} = we^{-i\theta}$; let $\mu(x, y)$ and $\mu_\theta(x, \hat{y})$ be the distribution of the absorption coefficient by the material of the object in the initial and in the rotated system of coordinates, respectively, $\mu_\theta(\hat{x}, \hat{y}) = \mu(x, y)$; the function μ(x, y) is called the image of the section of the object. Then for x rays passing along the straight line $\hat{x}$ = const, the logarithm of the ratio of its intensity at the entrance into the object to the intensity at the exit from the object, called the parallel tomographic projection $\rho_\theta(\hat{x})$ of the section, is determined by the formula

$$p_\theta(\hat{x}) = \int_{-\infty}^{+\infty} \mu_\theta(\hat{x}, \hat{y})\, d\hat{y}. \tag{1}$$

Assume that from the source lying at the point $\rho \exp\left[i\left(\beta - \frac{\pi}{2}\right)\right]$ there emerges a beam in the direction parallel to the vector $\exp\left[i\left(\frac{\pi}{2} + \beta + \gamma\right)\right]$; the logarithm of the ratio of its intensities at the entrance into and at the exit from the object is called the bundle projection $h_\beta(\gamma)$ of the section; it is correlated with the parallel projection by the relation [1]

$$h_\beta(\gamma) = p_{\theta(\beta,\gamma)}(\hat{x}(\beta, \gamma)), \tag{2}$$

where the dependences $\hat{x}(\beta, \gamma)$, $\theta(\beta, \gamma)$ have the form

$$\hat{x} = -\rho \sin\gamma, \quad \theta = \beta + \gamma. \tag{3}$$

We introduce the notation: l, n are integers, n = 1, 2, ..., N; l = 1, 2, ..., L_n; g(n, l) is the region bounded by an ellipse with the center at the point $R(n, l)\exp[i\varphi(n, l)]$, the semiaxis $a(n, l)$, $b(n, l)$, the first of which is inclined to the radius vector of the center of the ellipse at the angle $\Phi(n, l)$; if for some n_0, l_0 we have R (n_0, l_0) = 0, then we put $\varphi(n_0, l_0) = 0$; g(0) is the region bounded by an ellipse with the center at the origin of coordinates, semiaxes a(0), b(0), the first of which is inclined to the x axis at the angle Φ(0).

Let us examine the class of images μ(x, y) for which the following condition is fulfilled; the section of the object is the domain $g(0)$; $g(n, l) \subset g(0)$ for all n, l; the sets G(n), determined by the relation

$$G(n) = \bigcup_{l=1}^{L_n} g(n, l), \tag{4}$$

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do not intersect pairwise;

$$\mu(x, y) = \begin{cases} k(0), & w \in g(0) \setminus \bigcup_{n=1}^{N} G(n), \\ k(n), & w \in G(n), \end{cases} \quad (5)$$

where k(0) and k(n) are specified constants.

For any image $\mu(x, y)$ from the examined class, the parallel projections are expressed by the formula

$$p_\theta(\hat{x}) = k(0)\, p_\theta(0, \hat{x}) - \sum_{n=1}^{N} [k(0) - k(n)]\, p_\theta(n, \hat{x}), \quad (6)$$

the bundle projections are found from this with the aid of relations (2), (3). In formula (6) the value of $p_\theta(0, \hat{x})$ is determined by the equality

$$p_\theta(0, \hat{x}) = 2\sqrt{A(0)\,a(0)\,b(0) - A^2(0)\,\hat{x}^2}, \quad (7)$$

where

$$A(0) = \frac{\sin 2\alpha(0)}{1 - \cos 2\alpha(0) \cos 2[\Phi(0) - \theta]}, \quad (8)$$

$$\alpha(0) = \operatorname{arctg} \frac{a(0)}{b(0)}, \quad (9)$$

and the values of $p_\theta(n, x)$ are calculated in the following manner.

Specifying the values n, $\hat{x}$, θ, and putting l = 1, 2, ..., L_n; j = − 1, 1, we calculate $\hat{y}(n, l, j; \hat{x}, \theta)$ for all combinations of l, j by the formula

$$\hat{y}(n, l, j; \hat{x}, \theta) = R(n, l)\sin[\varphi(n, l) - \theta] + B(n, l; \theta) \times$$

$$\times C(n, l; \hat{x}, \theta) + (-1)^{\frac{3+j}{2}} \sqrt{A(n, l; \theta)a(n, l)b(n, l) - A^2(n, l; \theta)C^2(n, l; \hat{x}, \theta)}, \quad (10)$$

where

$$A(n, l; \theta) = \frac{\sin 2\alpha(n, l)}{1 - \cos 2\alpha(n, l) \cos 2[\varphi(n, l) + \Phi(n, l) - \theta]}, \quad (11)$$

$$B(n, l; \theta) = -\frac{\cos 2\alpha(n, l) \sin[\varphi(n, l) + \Phi(n, l) - \theta]}{1 - \cos 2\alpha(n, l) \cos 2[\varphi(n, l) + \Phi(n, l) - \theta]}, \quad (12)$$

$$C(n, l; \hat{x}, \theta) = R(n, l) \cos[\varphi(n, l) - \theta] - \hat{x}, \quad (13)$$

$$\alpha(n, l) = \operatorname{arctg} \frac{a(n, l)}{b(n, l)}. \quad (14)$$

We arrange the obtained set of values $\hat{y}(n, l, j; \hat{x}, \theta)$ (see (10)) in the form of a nondecreasing sequence of s, and denote:

$$\hat{y}(n, l_s, j_s; \hat{x}, \theta) = y(s), \quad s = 1, 2, \ldots, S. \quad (15)$$

The subscripts s for which the equality

$$\sum_{k=1}^{s} j_k = 0 \quad (16)$$

is fulfilled are arranged in the form of an increasing sequence of q: q = 1, 2, ..., Q. Then the sought value of $p_\theta(n, \hat{x})$ is determined by the expression

$$p_\theta(n, \hat{x}) = \sum_{q=1}^{Q} y(s_q) - \sum_{q=1}^{Q-1} y(s_q + 1) - y(1), \tag{17}$$

in the same way with the aid of formula (6) we find the parallel projection, and with a view to formulas (2), (3) we find the bundle projection for any image $\mu(x, y)$ from among the class under examination.

NOTATION

x, y, Cartesian coordinates; i, imaginary unit; r, φ, polar coordinates; $w = x + iy = r\exp(i\varphi)$; $\hat{w} = \hat{x} + i\hat{y} = w\exp(-i\theta)$; $\mu(x, y)$, absorption coefficient of radiation as a function of the coordinates (image of the section of the object); β, γ, bundle coordinates; $p_\theta(\hat{x})$, parallel tomographic projection; $h_\beta(\gamma)$, bundle tomographic projection.

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SURVEYS

INTERACTIONS OF ATOMS AND CALCULATION OF TRANSPORT COEFFICIENTS IN METAL VAPORS AND THEIR MIXTURES WITH GASES

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UDC 533.15

In kinetic theory [1, 2], the transport coefficients of a gas are expressed in terms of collision integrals. In particular, in the first approximation of the theory of Chapman and Enskog, the viscosity and thermal conductivity of a dilute, single-component gas, and the coefficient of diffusion of a dilute binary mixture are given by the formula

$$\eta = \frac{5}{16}\frac{\sqrt{\pi mkT}}{\pi\sigma^2\Omega^{(2,2)*}}, \tag{1}$$

$$\lambda = \frac{5}{2}\eta c_v \tag{2}$$

(for a monatomic gas),

$$D_{12} = \frac{3}{16nm_{12}}\frac{\sqrt{2\pi m_{12}kT}}{\pi\sigma_{12}^2\Omega_{12}^{(1,1)*}}. \tag{3}$$

The reduced collision integrals

$$\Omega^{(l,s)*} = \Omega^{(l,s)}\left\{\left(\frac{kT}{\pi m_{12}}\right)^{1/2}\frac{(s+1)!}{2}\left[1 - \frac{1+(-1)^l}{2(l+1)}\right]\pi\sigma_{12}^2\right\}^{-1}$$

are computed with the help of relations taking into account the interaction of molecules in collisions based on the conservation laws of mass, momentum, and kinetic energy:

$$\chi(g, b) = \pi - 2b\int_{R_m}^{\infty}\frac{dR/R^2}{[1 - b^2/R^2 - \varphi(R)/(m_{12}g^2/2)]^{1/2}},$$

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