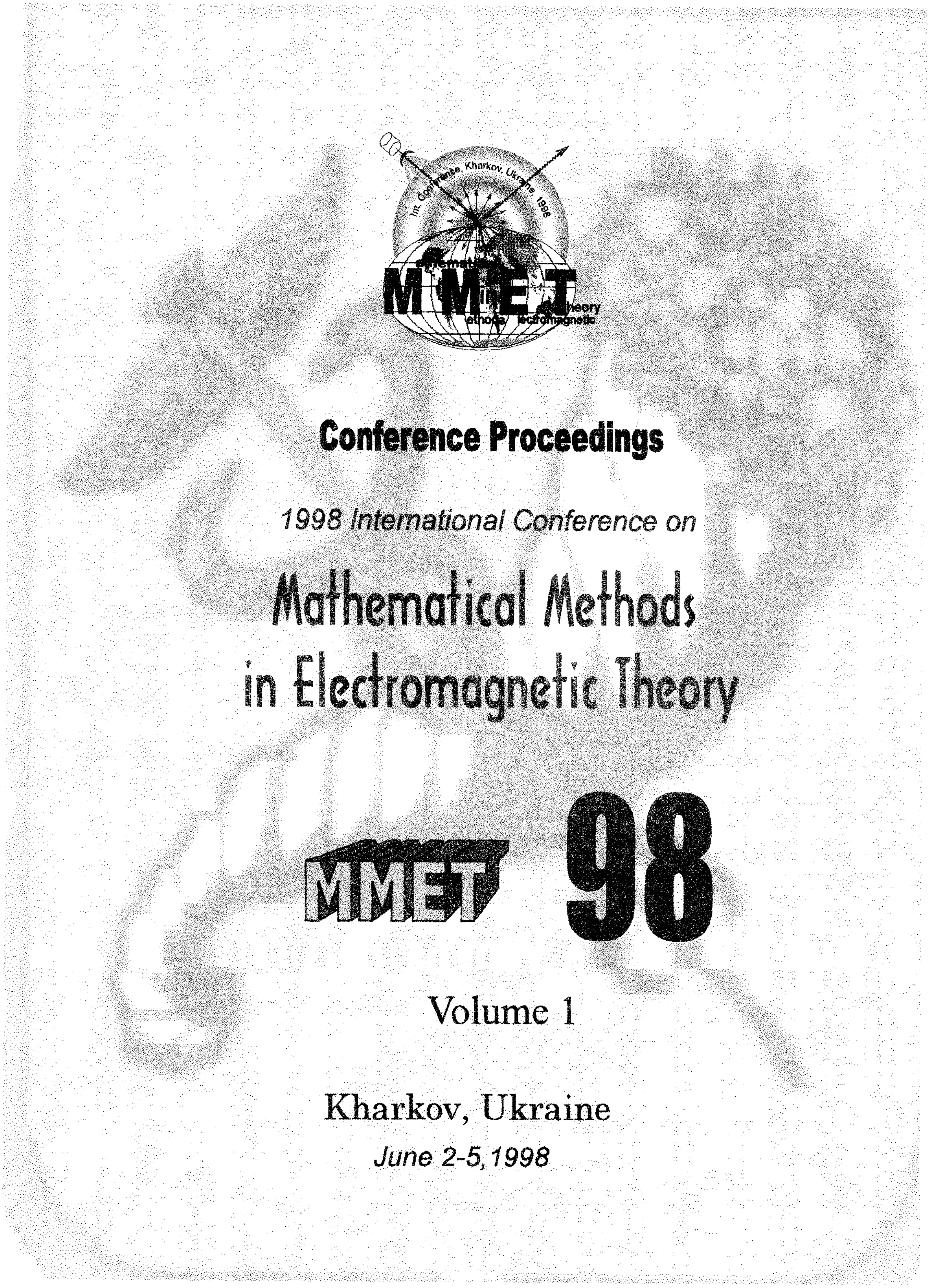

Conference Proceedings

1998 International Conference on

Mathematical Methods in Electromagnetic Theory

MMET 98

Volume 1

Kharkov, Ukraine

June 2-5, 1998

Organized and sponsored by

IEEE AP/MTT/ED/AES Societies East Ukraine Joint Chapter

in cooperation with

Ukrainian URSI Commission "B"

Institute of Radiophysics & Electronics
of the National Academy of Sciences of Ukraine

Institute of Radio Astronomy
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*We wish to thank the following co-sponsors for their contribution
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US Office of Naval Research European Office
INTAS – International Association

1998 International Conference on Mathematical Methods in Electromagnetic Theory

IEEE Catalog Number:	98EX114	
ISBN:	0-7803-4360-3	Softbound Edition
	0-7803-4361-1	Microfiche Edition
Library of Congress:	97-80498	

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MODEL OF SIGNALS FOR DIGITAL ANTENNA ARRAY WITH MUTUAL COUPLING ON THE BASIS OF FACE-SPLITTING MATRISES PRODUCT

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When considering the multicoordinate digital antenna arrays (DAA) with mutual coupling of channels there arises a problem of compact matrix record of the responses of reception channels. For the solution of the given problem it is proposed to operate with a special type of the product of matrices, named as "face-splitting" ($a \square b = \left[a_{ij} \cdot B_i\right]$) and "transposed face-splitting" product (TFSP) ($a \blacksquare b = \left[a_{ij} \cdot B_j\right]$), respectively, [1].

With the aid of TFSP it is possible to obtain the variant of analytical model of two-coordinate DAA with mutual coupling:

$$U = (F \otimes W)(Q \blacksquare V) \cdot A, \qquad (1)$$

where U is a block-vector of voltages of the responses of DAA channels, Q, V is the R×M matrix of the directivity characteristics of primary channels in azimuth and elevation angle planes,

$$Q = \begin{bmatrix} Q_1(x_1) & Q_1(x_2) & \cdots & Q_1(x_M) \\ Q_2(x_1) & Q_2(x_2) & \cdots & Q_2(x_M) \\ \vdots & \vdots & \vdots & \vdots \\ Q_R(x_1) & Q_R(x_2) & \cdots & Q_R(x_M) \end{bmatrix}, \quad V = \begin{bmatrix} V_1(y_1) & V_1(y_2) & \cdots & V_1(y_M) \\ V_2(y_1) & V_2(y_2) & \cdots & V_2(y_M) \\ \vdots & \vdots & \vdots & \vdots \\ V_R(y_1) & V_R(y_2) & \cdots & V_R(y_M) \end{bmatrix};$$

$$Q \blacksquare V = \left[\begin{array}{c:c:c:c} Q_1(x_1)\begin{bmatrix} V_1(y_1) \\ \vdots \\ V_R(y_1) \end{bmatrix} & Q_1(x_2)\begin{bmatrix} V_1(y_2) \\ \vdots \\ V_R(y_2) \end{bmatrix} & \cdots & Q_1(x_M)\begin{bmatrix} V_1(y_M) \\ \vdots \\ V_R(y_M) \end{bmatrix} \\ \hdashline Q_2(x_1)\begin{bmatrix} V_1(y_1) \\ \vdots \\ V_R(y_1) \end{bmatrix} & Q_2(x_2)\begin{bmatrix} V_1(y_2) \\ \vdots \\ V_R(y_2) \end{bmatrix} & \cdots & Q_2(x_M)\begin{bmatrix} V_1(y_M) \\ \vdots \\ V_R(y_M) \end{bmatrix} \\ \hdashline \vdots & \vdots & \vdots & \vdots \\ \hdashline Q_R(x_1)\begin{bmatrix} V_1(y_1) \\ \vdots \\ V_R(y_1) \end{bmatrix} & Q_R(x_2)\begin{bmatrix} V_1(y_2) \\ \vdots \\ V_R(y_2) \end{bmatrix} & \cdots & Q_R(x_M)\begin{bmatrix} V_1(y_M) \\ \vdots \\ V_R(y_M) \end{bmatrix} \end{array}\right];$$

F, W is the R×R matrix of mutual coupling,

$$F=\begin{bmatrix} 1 & F_{12} & \cdots & F_{1R} \\ F_{21} & 1 & \cdots & F_{2R} \\ \vdots & \vdots & \vdots & \vdots \\ F_{R1} & F_{R2} & \cdots & 1 \end{bmatrix}, \quad W=\begin{bmatrix} 1 & W_{12} & \cdots & W_{1R} \\ W_{21} & 1 & \cdots & W_{2R} \\ \vdots & \vdots & \vdots & \vdots \\ W_{R1} & W_{R2} & \cdots & 1 \end{bmatrix}, \quad |F_{nm}|<1, \ |W_{nm}|<1 ;$$

$A=\begin{bmatrix} \mathring{a}_1 & \mathring{a}_2 & \cdots & \mathring{a}_M \end{bmatrix}^T$ is the vector of complex amplitudes of signals of M sources.

With the aid of identities [2]:

$$(F \otimes W)(Q \blacksquare V) = (F \cdot Q) \blacksquare (W \cdot V),$$

one can obtain that

$$U = P \cdot A, \text{ where } P = (F \cdot Q) \blacksquare (W \cdot V) \qquad (2)$$

By using the method of maximum likelihood, an estimation of parameters of M sources of signals of two-coordinate DAA it is possible to be carried out, by a minimization of a functional not differing in form from that used in one-coordinate case. Indeed, it is possible to write down:

$$L = \{U - P \cdot A\}^* \{U - P \cdot A\} = \min$$

The measuring procedure in the wo-coordinate variant is reduced to the minimization of expression:

$$L = \mathrm{tr}\left[G \cdot R\right], \quad \text{where} \quad G = P \cdot (P^* \cdot P)^{-1} \cdot P^*, \quad R = U \cdot U^* .$$

With the account of (2), on the basis of matrix Neudecker derivative [3] an information fisher's block-matrix describing the accuracy of joint estimation of angular coordinates is obtained [4]:

$$I = \frac{1}{\sigma^2} \cdot \left[\begin{array}{ccc} P^T \cdot P & \vdots & (A^* \otimes P^T) \cdot \dfrac{\partial P}{\partial Y} \\ \cdots\cdots\cdots\cdots & \vdots & \cdots\cdots\cdots\cdots\cdots\cdots \\ \left(\dfrac{\partial P}{\partial Y}\right)^T \cdot (A \otimes P) & \vdots & \left(\dfrac{\partial P}{\partial Y}\right)^T \cdot (AA^* \otimes 1_{RR}) \cdot \dfrac{\partial P}{\partial Y} \end{array} \right],$$

where $\dfrac{\partial P}{\partial Y}$ is the Neudecker derivative of the matrix P by the vector Y formed by unknown estimations of angular coordinates of M sources; 1_{RR} is the identity matrix of dimension R × R; $\otimes$ is the symbol of Kronecker-products of matrices.

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