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The complexity analysis in [1] did not use (1), only the $1/R^2$ proportionality. Furthermore, it was assumed that, by choosing a sufficiently large number of blocks M, the interactions with minimum S would dominate. The above analysis shows that this is not true, whence the $\log N$ factor.

Numerical experiments indicate that the proportionality of S with k^2 is not yet observed even for sets of several hundreds of wave lengths in diameter. Consequently, the above complexity analysis applies to very large problems, well beyond the reach of even the largest existent computers. For moderate size problems, the "measured" complexity is lower, as illustrated by the numerical experiments in [1] and in [2].

REFERENCES

[1] A. Heldring, J. M. Rius, J. M. Tamayo, J. Parrón, and E. Ubeda, "Fast direct solution of method of moments linear system," *IEEE Trans. Antennas Propag.*, vol. 55, no. 11, pp. 3220–3228, Nov. 2007.

[2] K. Zhao, M. N. Vouvakis, and J.-F. Lee, "The adaptive cross approximation algorithm for accelerated method of moments computations of EMC problems," *IEEE Trans. Electromag. Compat.*, vol. 47, no. 4, pp. 763–773, Nov. 2005.

[3] O. M. Bucci, C. Gennarelli, and C. Savarese, "Representation of electromagnetic fields over arbitrary surfaces by a finite and nonredundant number of samples," *IEEE Trans. Antennas Propag.*, vol. 46, no. 3, pp. 351–359, Mar. 1998.

[4] A. S. Y. Poon, R. W. Brodersen, and D. N. C. Tse, "Degrees of freedom in multiple antenna channels: A signal space approach," *IEEE Trans. Inf. Theory*, vol. 51, no. 2, pp. 523–536, Feb. 2005.

Comments on "Decoupling Efficiency of a Wideband Vivaldi Focal Plane Array Feeding a Reflector Antenna"

Sergei P. Skobelev

***Index Terms*—Antenna array feeds, aperture efficiency, mutual coupling.**

The authors of [1] have made a good contribution with theoretical and experimental study of a dense focal plane array designed for new generation radio telescopes. Though this work is highly commendable, there are some oversights regarding non-citation of previous work that deserves comments.

1) The authors have adopted the term "decoupling efficiency" to describe the effectiveness of matching the focal plane array to the incident power. This replaces the term "coupling efficiency" used by them in some earlier conference papers, e.g., [2]. The inappropriateness of using the latter term was first indicated to the authors of [1] by the present author in private correspondence. Related to this, it is noted that the term "coupling efficiency" has already been adopted by the fiber optics community where its meaning is directly opposite to the present one. Though the appropriateness of the term "decoupling efficiency" still requires further discussion, the new name should help to avoid confusion.
2) In [1, Fig. 8], the authors have given the formula $\pi d_x d_y/\lambda^2$ for the ideal efficiency of a small radiating element imbedded in an infinite dense array with a reference to their recent paper [3] in [1, Ref. [16]]). Such a reference may create the incorrect impression about the origin of the formula determining the ideal array element efficiency. This concept was originally considered in [4] and [5], and the expression for the ideal element efficiency is given in [5, formula (8), p. 535] in the form $\eta = \pi a_1 a_2$ where a_1 and a_2 are the element spacings, expressed as fractions of the wavelength, in two orthogonal directions. The authors' formula differs from the formula in [5] only by notation.

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REFERENCES

[1] M. V. Ivashina, M. Ng Mou Kehn, P.-S. Kildal, and R. Maaskant, "Decoupling efficiency of a wideband Vivaldi focal plane array feeding a reflector antenna," *IEEE Trans. Antennas Propag.*, vol. 57, no. 2, pp. 373–382, Feb. 2009.

[2] M. V. Ivashina, M. Ng Mou Kehn, P.-S. Kildal, and M. Franzen, "Radiation efficiency as a fundamental limitation of wideband dense arrays for multi-beam applications," in *Proc. 29th ESA Antenna Workshop on Multiple Beams and Reconfigurable Antennas, ESTEC*, Noordwijk, The Netherlands, Apr. 18–20, 2007, pp. 118–121.

[3] M. Ng Mou Kehn, M. V. Ivashina, P.-S. Kildal, and R. Maaskant, "Definition of unifying decoupling efficiency of different array antennas—Case study of dense focal plane array feed for parabolic reflector," *Int. J. Electron. Commun. (AEU)*, 2009, 10.1016/j.aeue.2009.02.011.

[4] P. W. Hannan, "The element-gain paradox for a phased-array antenna," *IEEE Trans. Antennas Propag.*, vol. AP-12, pp. 423–433, Jul. 1964.

[5] W. K. Kahn, "Ideal efficiency of a radiating element in an infinite array," *IEEE Trans. Antennas Propag.*, vol. 15, no. 4, pp. 534–538, Jul. 1967.

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Reply to "Comments on 'Decoupling Efficiency of a Wideband Vivaldi Focal Plane Array Feeding a Reflector Antenna'"

Marianna V. Ivashina, Malcolm Ng Mou Kehn, Per-Simon Kildal, and Rob Maaskant

***Index Terms*—Antenna array feed, aperture efficiency, decoupling efficiency, mutual coupling, radiation efficiency.**

I. INTRODUCTION

The authors of [1] wish to thank Prof. Skobelev for complimenting their work and for his comments [2]. Below is their response to these comments.

Answer to comment 1: The inappropriateness of the term "coupling efficiency" may have been mentioned in a private communication. However, the term was changed after one of the author's (Kildal)

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Ph.D. student's Nima Jamaly, who works on MIMO antennas and their characterization, suggested that the term gave wrong associations, because high efficiency is obtained with low coupling. Therefore, the terminology in [1] was changed to "decoupling efficiency." Thus, the change had nothing to do with the term adopted by the fiber optics community.

Answer to comment 2: We apologize for omitting the earlier references. However, the reviewers of the original version of paper [1] requested a significant condensation of the reference list without losing relevant information. In this sense, the given references in paper [1] do provide pointers to the most significant works and include the recent paper of Kahn [3] which refers to his earlier paper [4] from 1967. Finally, it is important to mention that to our knowledge we are the first to verify by measurement that the decoupling efficiency follows the formula $\pi \mathrm{d_x}\,\mathrm{d_y}/\lambda^2$ in a dense array with element spacing smaller than $\lambda/2$ [1], [5].

REFERENCES

[1] M. V. Ivashina, M. Ng Mou Kehn, P.-S. Kildal, and R. Maaskant, "Decoupling efficiency of a wideband Vivaldi focal plane array feeding a reflector antenna," *IEEE Trans. Antennas Propag.*, vol. 57, no. 2, pp. 373–381, Feb. 2009.

[2] S. P. Skobelev, "Comments on 'Decoupling efficiency of a wideband Vivaldi focal plane array feeding a reflector antenna'," *IEEE Trans. Antennas Propag.*, vol. 58, no. 3, p. 1016, Mar. 2010.

[3] W. K. Kahn, "Element efficiency: A unifying concept for array antennas," *IEEE Antennas Propag. Mag.*, vol. 49, pp. 48–56, 2007.

[4] W. K. Kahn, "Ideal efficiency of a radiating element in an infinite array," *IEEE Trans. Antennas Propag.*, vol. 15, no. 4, pp. 534–538, Jul. 1967.

[5] M. N. M. Kehn, M. V. Ivashina, P.-S. Kildal, and R. Maaskant, "Definition of unifying decoupling efficiency of different array antennas—Case study of dense focal plane array feed for parabolic reflector," *Int. J. Electron. Commun.*, to be published.