

A further improvement in the Gaussian $\Theta(\rho z)$ approach for matrix correction in quantitative electron probe microanalysis

Citation for published version (APA): Bastin, G. F., Heijligers, H. J. M., & Loo, van, F. J. J. (1986). A further improvement in the Gaussian $\Theta(\rho z)$ approach for matrix correction in quantitative electron probe microanalysis. Scanning, 8(2), 45-67. https://doi.org/10.1002/sca.4950080204

DOI: 10.1002/sca.4950080204

Document status and date:

Published: 01/01/1986

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.

• The final author version and the galley proof are versions of the publication after peer review.

• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- · Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
 You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Original Paper

A Further Improvement in the Gaussian $\Phi(qz)$ Approach for Matrix Correction in Quantitative Electron Probe Microanalysis

G. F. Bastin, H. J. M. Heijligers and F. J. J. van Loo

Laboratorium for Physical Chemistry, University of Technology, P. O. Box 513, 5600 MB Eindhoven, The Netherlands

Abstract

An improved correction model for quantitative electron probe microanalysis, based on modifications of the Gaussian $\Phi(\varrho z)$ approach, originally introduced by *Packwood* and *Brown*, is presented. The improvements consist of better equations for the input parameters of this model which have been obtained by fitting to experimental $\Phi(\varrho z)$ data. The new program has been tested on 627 measurements for medium to heavy elements (Z>11) and on 117 carbon measurements with excellent results: an r.m.s. value of 2.99% in the former case and 4.1% in the latter. Finally the new program has been compared to five other current correction programs which were found to perform less satisfactorily.

1. Introduction

For many years it has been common practice in quantitative electron probe microanalysis to treat the matrix correction procedure, necessary in order to convert the measured intensity ratios (k-ratios) into concentration units, in three separate steps:

- Firstly, a step in which backscattering of the electrons and x-ray generation in the target are separately considered in detail.

Both effects, called the R-factor (backscattering) and the S-factor (stopping power), respectively, are then combined to make up for the so-called atomic number correction, which is usually expressed by Z. This Z-factor is proportional to the total number of ionisations generated in the target.

- Secondly, it is necessary to adopt some kind of $\Phi(\varrho z)$ curve (number of ionisations Φ , as a function of mass depth ϱz) in order to calculate how much of the generated intensity is lost by absorption in the target on its way to the spectrometer.

The ratio between the *emitted* and the *generated* intensity is called the A-factor, which is more commonly known as the quantity $F(\chi)$, in which

$$\chi = \frac{\mu}{\varrho} \operatorname{cosec} \psi \tag{1}$$

(μ/ϱ is the mass absorption coefficient and ψ is the x-ray take-off angle).

 Finally, it is sometimes necessary to account for secondary fluorescence which can take place whenever one of the primary, electron beam generated, radiations is of sufficiently high energy to excite additional x-radiation of the element being measured. The correction for this effect is contained in the so-called F-factor. The three factors Z, A and F are next calculated for standards and specimen and subsequently multiplied by the measured intensity ratio k of the element in question to yield the desired concentration c (in wt %) according to the relation

$$c = k Z A F.$$
 (2)

Note that now terms like Z stand for the ratio between the intensity generated in the standard and that in the specimen. For details regarding the procedures followed in performing the corrections until a few years ago the reader is referred to the review article by *Beaman* and *Isasi* (1972).

Of all the three correction factors involved the absorption correction has rightfully received the most attention because this usually constitutes the major correction required. The performance of any absorption correction procedure is completely dependent on the correctness of the $\Phi(qz)$ curve used. In this respect quite an evolution has taken place: from the original simplified *Philibert* (1963) model, which was later modified (*Ruste* and *Zeller* 1977) into the full *Philibert* (1963) model, through more or less rudimentary forms of $\Phi(qz)$ curves like rectangles (*Bishop* 1974, *Love* and *Scott* 1978, 1980) and quadrilateral shapes (*Sewell* et al. 1985) to the more sophisticated and realistic models introduced recently (*Packwood* and *Brown* 1981, *Pouchou* and *Pichoir* 1984).

In the latter two models, the artificial separation into atomic number and absorption effects is avoided altogether. Instead, the combined correction is carried out in one single procedure. All that is required is the integration of the *emitted* intensity vs. ϱz curve (see Fig. 1). This curve is obtained by multiplying each point of the *generated* $\Phi(\varrho z)$ curve by exp [- $\chi \varrho z$] in order to correct for absorption.

Subsequent integration for ϱz between zero and infinity immediately yields the quantity that is proportional to the *emitted* intensity. If it should be necessary to know the absorption factor $F(\chi)$, one simply integrates both the generated as well as the emitted intensity and the ratio will yield $F(\chi)$.

The latter models rely even more on the correctness of the $\Phi(\varrho z)$ curves because now the complete [ZA] correction is based on the $\Phi(\varrho z)$ curves generated by the models, contrary to the conventional ZAF approaches. Hence, it is of the utmost importance that the equations used in the calculations of $\Phi(\varrho z)$ curves in both $\Phi(\varrho z)$ models are sufficiently reliable. Both the Packwood and Brown, as well as the Pouchou and Pichoir models use four parameters to describe the $\Phi(\varrho z)$ curves. In the latter model $\Phi(\varrho z)$ is characterised by:

- 1. the surface ionisation $\Phi(0)$,
- 2. the ultimate depth of ionisation,
- 3. the depth of maximum ionisation (peak position),
- 4. the integral of $\Phi(\varrho z)$, which is proportional to the number of ionisations *generated* by the incident electron.

Keeping the first three parameters fixed, a $\Phi(\varrho z)$ curve is generated with a height sufficient to ensure that the integral of $\Phi(\varrho z)$ is equal to parameter four. Although mathematical details of the Pouchou and Pichoir model have not been published so far, it is certain that a large amount of computational effort through complex equations is involved.

The Packwood and Brown model, which offers a substantial improvement in matrix correction procedures, is based on a completely different approach and is mathematically much simpler.

This model is based on the fact that $\Phi(\varrho z)$ curves are basically Gaussian in shape with the peak of the Gaussian centered at the surface. The so-called "undisturbed" Gaussian (dotted curve in Fig. 1) is then described by

$$\gamma = \exp\left[-\alpha^2 \left(\varrho z\right)^2\right] \tag{3}$$

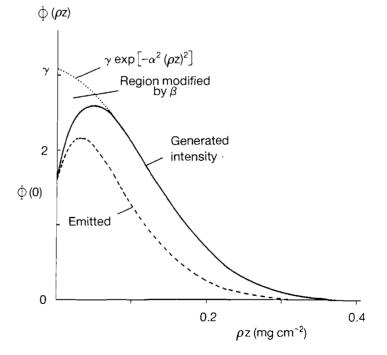


Fig. 1 Drawing showing the principles of the Gaussian $\Phi(qz)$ approach. Both the generated intensity (solid curve) as well as the emitted intensity (broken curve) as a function of mass depth (qz) are shown. The dotted curve represents the hypothetical "undisturbed" Gaussian which is centered at the surface with amplitude γ . The decay rate in the Gaussian is given by α .

SCANNING Vol. 8, 2 (1986)

in which α is the decay rate in the Gaussian and γ the value of its maximum. The real Φ (ϱz) curve, however, is known to have its maximum somewhere deeper in the specimen and this is accounted for by the introduction of a transient function:

$$\left[1 - \frac{\gamma - \Phi(0)}{\gamma} \exp(-\beta \varrho z)\right]$$
 (4)

in which β is some kind of scattering factor which contributes to a spreading of the electron beam, making it finally a diffuse electron cloud. Summarizing, $\Phi(\varrho z)$ can be described by:

$$\Phi(\varrho z) = \gamma \left[1 - \frac{\gamma - \Phi(0)}{\gamma} \exp(-\beta \varrho z)\right] \exp\left[-\alpha^2 (\varrho z)^2\right]$$
(5)

It will be evident that the success of the $\Phi(\varrho z)$ equation is strongly dependent on a correct parameterisation of the 4 input parameters α , β , γ and $\Phi(0)$.

The equations originally proposed by Packwood and Brown (1981), which were obtained through fits to measured $\Phi(\rho z)$ data, have been abandoned by the authors themselves (Brown and Packwood 1982) after testing them in a correction program on a large number of microanalyses. The reported value of 11.3% for the relative root-mean-square error (r.m.s.) would indeed suggest that it was one of the least accurate correction programs. In the same paper the authors produced new expressions for α and β , this time through an optimization process using the same data base. As a result they claimed an r.m.s. value of 4.8%, which would be very good indeed. However, we have shown that this claim was not correct and we carried out our own optimization (Bastin et al. 1984-1, 1984-2) with the result that our version of the Packwood and Brown model could match the results of the best programs then known. We have since tested (Bastin and Heijligers 1986) the same program on a set of 117 carbon measurements on 13 binary carbides between 4 and 30 kV, with excellent results: an r.m.s. value of 3.7% which must be called a remarkable achievement considering the wide range of accelerating voltages. Nevertheless, there were still some things which could be improved in the approach and these concerned, amongst other things, the $\Phi(\rho z)$ curves for high-energy radiations in heavy matrices, e.g. the case of $Bi - L\alpha$ in Au or $Zn - K\alpha$ in Cu.

In those and similar cases it was observed that although the calculated $\Phi(\varrho z)$ curves had a good shape and in general the peak at the right position, the absolute heights of the curves could not be brought into agreement with measured $\Phi(\varrho z)$ curves. We have previously concluded (*Bastin* et al. 1984-1) that our modified expression for α was probably reliable because it provided good fits to experimental data. However, we expressed our doubts about the equations for β and γ .

The object of the present work was to develop better equations for these parameters, not by optimization but by a renewed fitting procedure to experimental $\Phi(qz)$ curves in order to arrive at new empirical equations for β and γ .

Subsequently the new set of equations have been tested in a correction program applied to a large number of analyses and compared to other programs.

2. Mathematical Analysis of the Functional Behaviour of β and γ

In order to establish the influence of the parameters β and γ on the general shape of the $\Phi(\varrho z)$ curve, and more specifically on the absolute height and the position of the maximum, two rather extreme cases were selected: one at an extremely high overvoltage ratio, e.g. C-K α radiation in Carbon at 40 kV (with an overvoltage ratio of 141; Fig. 2a), and one at a rather low overvoltage ratio, e.g. Bi-L α in Au (overvoltage ratio 2.16; Fig. 2b).

In Fig. 2a a number of calculations have been performed with varying values of γ and β . It is shown that when β is varied between zero and infinity for a fixed value of γ , then the position of the maximum follows a loop extending from $\Phi(0)$ ($\beta = 0$) up to γ ($\beta = \infty$).

It can be shown that the mathematical description of the loop, which is simply the locus of the maximum, is given by

$$\beta = \frac{2\alpha^2 x_m \Phi(m)}{[\gamma \exp(-\alpha^2 x_m^2) - \Phi(m)]}$$
(6)

in which x_m is the position of the maximum in units of ρz and Φ (m) is the height of the maximum.

Three distinct regions in the loop can be distinguished:

- Firstly, a part close to γ , where a variation of β produces a variation in the peak position, and not so much in the peak height.
- Secondly, a part where the loop is almost vertical and where a variation in β produces a very strong variation in the peak height and hardly influences the position of the peak.

- Finally, a part close to Φ (0) where a variation in β produces mainly a variation in the peak position again.

48

This last part of the loop has no physical meaning because it is inconceivable that the peak should move closer to the surface again after having moved away from it first with increasing voltage.

It is interesting to note in Fig. 2a that even substantial changes in the values for γ (e.g. from 5 to 7) and β (e.g. from 800 to 1700) have hardly any influence on the peak position, because they both operate in the vertical part of the loop. They mainly affect the peak height. Because we had the distinct impression that for high overvoltage ratios in light matrices the maximum of the $\Phi(\varrho z)$ curves went increasingly too high, it is obvious that in such cases both the parameters β and γ could be responsible. However, the variation of γ with overvoltage is known to be very slow in this region; hence, it is most likely that the calculated values for β are increasingly too high.

The equation for β used previously was

$$\beta = 0.4 \alpha \frac{Z^{1.7}}{A} (U_o - 1)^{0.3}$$
 (7)

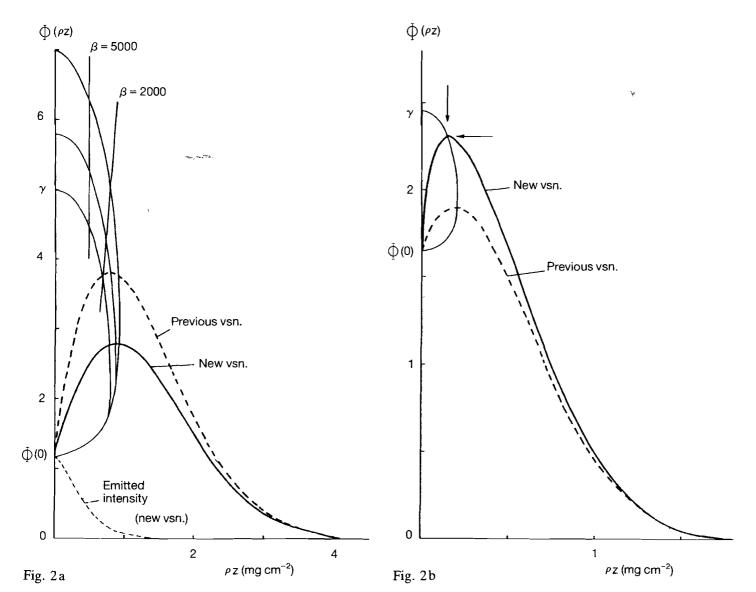


Fig. 2 Influence of the magnitude of β and γ on the shape of the calculated $\Phi(\varrho z)$ curve for two extreme cases: (a) Very high overvoltage ratio (approx. 140) in very light matrix (C-K α in C at 40 keV). The loops are the locus of the maximum in the $\Phi(\varrho z)$ curve when for a fixed value of γ (5, 5.8 and 7, respectively) β is varied between zero (lower end of loop) and infinity (upper end of loop). Dashed and solid curves are the $\Phi(\varrho z)$ curves calculated by our previous and present program, respectively. Lower dashed curve is the emitted intensity according to the present program (mass absorption coefficient 2373, take-off angle 40°). The straight lines show the variation in the position of the maximum for fixed values of β and varying values of γ . (b) Low overvoltage ratio (2.16) in heavy matrix (Bi-L α in Au at 29 keV). Arrows indicate the experimentally determined (*Castaing* and *Descamps* 1955) position of the maximum.

in which Z and A are atomic number and weight of the matrix element and U_o is the overvoltage ratio (E_o/E_c , E_o is acceleration voltage, E_c is critical excitation voltage).

It will immediately be clear that the factor $(U_0-1)^{0.3}$, which was brought in through an optimization process using a data base of microanalyses, is responsible for the malfunctioning of β in cases like Fig. 2a because β may attain unrealistically high values for very high overvoltage ratios.

Hence, it follows that in developing a new expression for β special attention has to be paid to a proper behaviour of β at high overvoltage ratios in light matrices, which means generally lower β -values in those cases.

Next we shall consider the case depicted in Fig. 2b, where the situation is completely different. Because γ and $\Phi(0)$ are much closer together, a small change in γ may have a relatively larger influence on raising or lowering the maximum. The largest influence will be felt when U_o decreases towards unity, which means that γ should approach $\Phi(0)$ and both should approach unity. We have criticized (*Bastin* et al. 1984-1) *Packwood* and *Brown's* original equation for γ (*Packwood* and *Brown* 1981) in this respect because their expression had a limiting value of $\pi/2$ at U_o = 1. Our own expression, again obtained through optimizing, was

$$\gamma = \frac{4.9 \pi U_o}{(U_o - 1) \ln U_o} (\ln U_o - 5 + 5 U_o^{-0.2}) \exp (0.001Z)$$
(8)

This still suffers from the same shortcoming. After comparing our calculated $\Phi(\varrho z)$ curves with experimental $\Phi(\varrho z)$ data we concluded that as far as γ is concerned we need a new expression which

- (a) provides a limiting value of 1 for $U_0 \rightarrow 1$, and
- (b) exhibits a faster increase between $U_o = 1$ and, say, $U_o = 3$.

At higher overvoltage ratios the absolute magnitude of γ slowly becomes less relevant. However, in order to ensure a smooth functioning it is necessary to develop a new expression for the whole range.

A close inspection of Fig. 2b reveals that a change in γ alone can never bring the peak position to the measured location (indicated by arrows). Apparently also a significant change in β is necessary.

A detailed comparison between available $\Phi(\varrho z)$ data for cases like in Fig. 2b and calculated $\Phi(\varrho z)$ curves showed that in general much too low values for β were calculated but that the peak position itself was quite satisfactory in the majority of cases. We came to the conclusion that for light element radiation the expression for β used so far brought the peak somewhere at an optimum position in the upper half of the loop, where it should be. In the case of higher energy-radiations the optimum in the peak position was usually in the lower half of the loop, which has no physical meaning.

This is the quite logical result of developing equations through an optimization process: Optimization will lead to a setting for β which will be best in those areas where it matters most; i.e. in lighter element radiations (Al – K α , Si – K α) in medium to heavy matrices where serious absorption can occur. Thus one ends up with an expression which yields fairly realistic $\Phi(\varrho z)$ curves for peak positions and, to a lesser extent, peak heights.

This conclusion is substantiated by the apparent success of our previous program (*Bastin* et al. 1984-2) on a data base containing medium to heavy element analyses and even more so by its success in Carbon analyses (*Bastin* and *Heijligers* 1986). On the other hand it is possible, and even likely, that an optimization process yields an expression for β that is less suited to a description of $\Phi(\varrho z)$ curves of high-energy radiations in heavier matrices, i.e. cases where it matters less, because heavy absorption is rarely encountered here and usually atomic number effects prevail, which are generally much smaller than absorption effects.

Moreover, for use in a correction program it is the ratio between quantities in standard and specimen that matters and even a fairly bad program can turn out acceptable results by a process of error compensation.

Summarizing, we come to the conclusion that the previous equation for β produced too high values for very high overvoltages, fairly realistic values for e.g. Al – K α and Si – K α radiations, and too low values for high energy radiations in heavy matrices. Apparently the setting for β used so far is a kind of "weighted average" throughout the periodic system. Hence, it needs to be reexamined and we chose to do this by a critical reexamination of existing experimental $\Phi(\varrho z)$ data.

3. Development of New Equations for β and γ

When trying to establish new empirical equations for β and γ , using measured $\Phi(\varrho z)$ curves one is confronted with a number of practical problems. In spite of the rather extensive data available (see e.g. Scott and Love 1983 for a review of existing $\Phi(\varrho z)$ data) it is difficult to find consistent series of measurements over a wide range of accelerating voltages. In those few systems where this is the case one is frequently trapped in inconsistencies or deviations between measurements by different authors. Experimental difficulties in this tedious and cumbersome type of work are no doubt responsible for this.

In the fitting procedure for β and γ , one thus usually has only a very limited region for each system to fit values of β and γ – in the vast majority of cases only two to four points which are usually closely spaced. For another system two or three new data points are available, which give access to values of β and γ in a sometimes completely different region of U_o, etc.

Besides, each $\Phi(\varrho z)$ curve is valid only for one type of radiation in one single matrix element. It is obvious, therefore, that a lot of fragmentary evidence has to be joined together in order to arrive at consistent expressions for β and γ for a wide range of overvoltage ratios. Monte-Carlo simulations could be considered in a number of cases. The latest evidence in this field, however (Sewell et al. 1985), seems to suggest that simulated $\Phi(\varrho z)$ curves are usually worse than measured ones.

The fitting procedure was carried out using, amongst other things, the extensive data gathered by Brown and Parobek (e.g. 1976) and Parobek and Brown (e.g. 1978), supplemented by measurements of Castaing and Descamps (1955), Castaing and Henoc (1966) and Shinoda (1966). Furthermore, in a number of cases $\Phi(\varrho z)$ curves generated by the *Pouchou* and Pichoir (1984) program were used. These were obtained in a mutual comparison (Pouchou and Pichoir 1985) of $\Phi(\varrho z)$ curves generated by their as well as our (previous) program and they obviously have the benefit of being supported by a separate expression for the total number of ionisations produced, which ensures that the variation of generated intensity with accelerating voltage is consistent. As far as can be judged from the impressive result (Pouchou and Pichoir 1984) this approach is successful.

3.1 New expression for γ

In section 2 we have discussed what the main requirements for γ should be:

- 1. Its value should approach unity for $U_0 \rightarrow 1$.
- 2. Its increase for $1 < U_o < 3$ should be faster than in either *Packwood* and *Brown's* (1981) original equation or our modified version (*Bastin* et al. 1984-1, 1984-2).

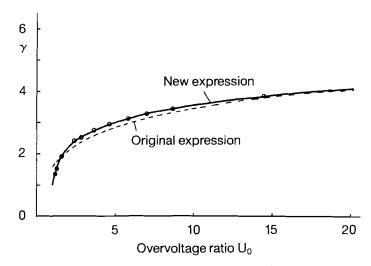


Fig. 3 Comparison between the original (*Packwood* and *Brown* 1981) and the new equation for γ , obtained by fitting to experimental $\Phi(\varrho z)$ data. Open circles denote some of the fitted data.

Figure 3 shows the result of the fitting procedure for γ (solid line) as compared to the original equation of *Packwood* and *Brown* (1981) (dotted line). A number of data points obtained by fitting have been indicated. Considering the scatter in the measured $\Phi(\varrho z)$ data it is surprising to see how smooth a variation of γ with U_o is obtained.

It proved very difficult to find one simple mathematical function to represent the fitted graph. It is very interesting to note, though, that for $U_o > 3$ the new γ -values for a certain value of U_o are approximately equal to the original γ -value calculated at $(U_o + 1)$

$$\gamma_{\text{new}} (U_{\text{o}}) = \gamma_{\text{old}} (U_{\text{o}} + 1)$$
(9)

It was, therefore, decided to make a distinction between two discrete regions in U_0 : one for $1 \le U_0 \le 3$ and one for $U_0 > 3$.

In the former case satisfactory γ -values could be calculated by the fitted expression

$$\gamma = 1 + (U_o - 1)/[0.3384 + 0.4742 (U_o - 1)]$$

$$(1 \le U_o \le 3)$$
(10)

whereas in the latter case simply the value of $(U_0 + 1)$ was inserted in Packwood and Brown's original equation, to yield:

$$\gamma = \frac{5\pi(U_o + 1)}{U_o \ln(U_o + 1)} [\ln(U_o + 1) - 5 + 5 (U_o + 1)^{-0.2}] (U_o > 3)$$
(11)

A final remark on γ must be made as far as high overvoltages (U_o > 25) are concerned. Due to an obvious lack of $\Phi(\varrho z)$ data in this range the values for γ are necessarily somewhat speculative.

3.2 New expression for β

According to *Packwood* and *Brown* (1981) the parameter β is related to the rate at which the focussed electron beam becomes randomized through electron scattering in the target. Hence, it would appear that β could be calculated using electron scattering equations. However, their original equation has been abandoned (*Packwood* and *Brown* 1982) in favour of an equation in which β was related to α . This was justified by the assumption that both α and β are to a certain extent subject to the same scattering laws and hence, there should be a close relationship between the two quantities.

We also followed the latter approach, apparently with success (*Bastin* et al. 1984). However, there are some areas in which the behaviour of our expression for β was unsatisfactory. In the present work we will try to find a new expression for β , which relates β to α according to an equation of the type

$$\beta = \alpha \, \frac{Z^n}{A} \tag{12}$$

in which the value of n has to be determined from experimental $\Phi(\varrho z)$ data. Note that now no effort is made to include a term containing U_o , as this was found to cause errors at high overvoltages.

When trying to establish the value of the exponent n it was soon realized that this could never have a constant value throughout the periodic system. Figure 4 shows the variation of n with atomic number Z.

A number of representative data points, obtained by backcalculation and fitting, have been included. The error bars indicate the most likely range for n, corresponding to the possible variation in β , arising from measuring uncertainties etc. Due to the proportionality to Zⁿ, the value of n becomes all the more important for very high atomic numbers. For low atomic numbers, on the other hand, the value of n is less critical.

A satisfactory fit to the data points was obtained by the following equation:

$$\mathbf{n} = \mathbf{Z} / (0.4765 + 0.5473 \times \mathbf{Z}) \tag{13}$$

It is tempting, to try to explain the observed variation of n with Z in terms of the growth of the electron cloud with increasing atomic number. However, the final equation for β becomes rather complicated through its reationship with α . We satisfy ourselves with the empirical relationship. The final equations for α (*Bastin* et al. 1984), β and γ are thus

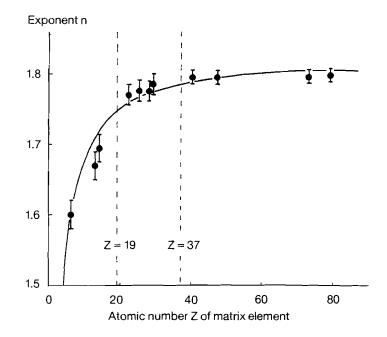


Fig. 4 Variation of the exponent n in the equation $\beta = \alpha Z^n/A$ with atomic number Z of the matrix element. Solid points are fitted data points; error bars indicate estimated uncertainty. Solid curve represents the equation for β fitted through these data points. Broken vertical lines indicate the regions with different growth rates of n.

$$\alpha = \frac{1.75 \times 10^5}{E_o^{1.25} (U_o - 1)^{0.55}} \left[\frac{\ln(1.166E_o/J)}{E_c} \right]^{0.5}$$
(14)

in which J is the ionisation potential.

$$\beta = \alpha \frac{Z^{u}}{A}, \text{ with } n = Z / (0.4765 + 0.5473 \times Z)$$

$$\gamma = 1 + (U_{o} - 1) / [0.3384 + 0.4742 \times (U_{o} - 1)] \text{ for } 1 \leq U_{o} \leq 3$$

$$5\pi(U_{o} + 1) \quad \text{ff} (U_{o} + 1) = 5 + 5 (U_{o} + 1)^{-0.21}$$

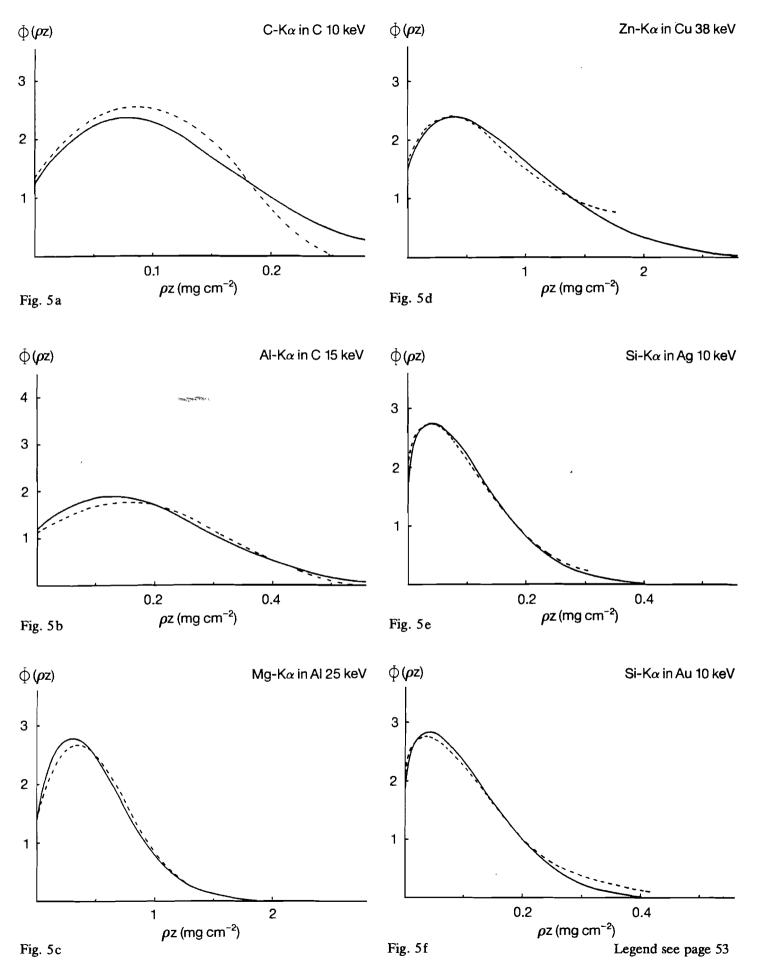
$$\gamma = \frac{5\pi(U_0+1)}{U_0 \ln (U_0+1)} \left[\ln(U_0+1) - 5 + 5 (U_0+1)^{-0.2} \right]$$

for U₀ > 3

The expression for J we use is that of *Ruste* (1979) while the expression for Φ (0) is that of *Love* et al. (1978).

4. Comparison Between Experimental and Calculated $\Phi(\rho z)$ Curves

We shall now compare the calculated $\Phi(\varrho z)$ curves, using the new equations for β und γ , to experimental $\Phi(\varrho z)$ data. Figures 5a-5g show a number of calculated $\Phi(\varrho z)$ curves which have been selected to give a 52



SCANNING Vol. 8, 2 (1986)

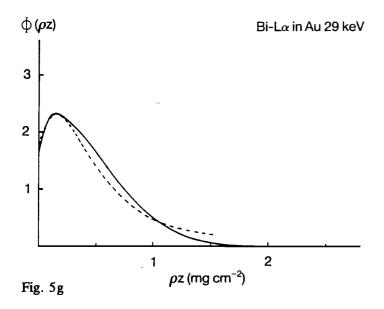


Fig. 5 Comparison between a number of calculated $\Phi(qz)$ curves according to the present version (solid lines) and experimental $\Phi(qz)$ data (broken curves). All experimental curves have been obtained by tracer measurements, except Fig. 5a, which was obtained by Monte-Carlo simulations. References: (a) Love and Scott 1980, (b) Sewell et al. 1985, (c) Castaing and Hénoc 1966, (d) Shinoda 1966, (e) Brown and Parobek 1976, (f) Brown and Parobek 1976, (g) Castaing and Deschamps.

representative cross-section through the periodic system. With one exception (Fig. 5a) the experimental $\Phi(\varrho z)$ data have also been represented (broken lines). The only exception concerned the case of C-K α radiation in C, for which system no experimental data are available for obvious reasons. Instead, the results of Monte Carlo simulations (*Love* and *Scott* 1980) have been used here. The general impression from Fig. 5 is that the new expression for β and γ are apparently highly successful in modeling the $\Phi(\varrho z)$ curves correctly, the more so when the wide range of systems and experimental contitions is considered.

Our conclusion seems, therefore, justified that the new set of equations is capable of predicting $\Phi(\varrho z)$ curves for a wide variety of conditions within the experimental error. A comparison with calculations based on the previous equations showed that the main improvement was achieved for higher-energy radiations in heavy matrices (cf. Figs. 2b and 5g). For lighter element radiations like Al-K α the new results are virtually the same as the previous ones, whereas for very light element radiation like C-K α the improvement probably concerns mainly a reduction of the (excessive) peak heights at extreme overvoltages (see Fig. 2a). These are exactly the objectives mentioned in the introduction.

5. Test of the New Equations in a Matrix Correction Program

5.1 Some general remarks

The usual way of testing a correction program is to subject it to a large number of microanalyses, calculate the k-ratio (k') for the known composition in each case and compare it to the measured k-ratio (k). The proximity of k'/k to 1 is used as a measure of success.

A convenient way of displaying the results is in a histogram representing the number of analyses as a function of k'/k. The narrowness of the histogram (usually expressed in terms of the relative rootmean-square error (r.m.s) with respect to the average k'/k value) and its shape are used as the final measures of success. Several demands have to be made upon such a test:

1. The data base used should be of a very high quality and should contain analyses of a widely varying nature, performed over a wide range of accelerating voltages.

We have previously criticized (*Bastin* et al. 1984) the data base used so far (*Love* et al. 1975) in these respects. Our main objection was that a large proportion of the data were really too old (from before 1968).

2. A test should be meaningful. If it is desired to show that one absorption correction is better than another, one should select a large number of heavy absorption cases. In their latest paper Sewell, Love and Scott (1985) have done the opposite. From their original set of 430 analyses they eliminated virtually all cases of heavy absorption. These mainly concerned large series of Al-K α and Si-K α measurements (Thoma 1970), specially performed at three different take-off angles with the specific purpose of comparing the performances of correction programs.

Nevertheless, the remaining 313 analyses were supplemented by 168 analyses on Au-Cu and Au-Ag alloys, published by *Heinrich* et al. (1971) and a number of analyses (frequently on non-conducting systems) produced by the authors themselves. A total number of 554 analyses were thus accumulated and used as a "heavy element" data base on which a number of correction programs were compared.

Sewell et al. also used a data base of 94 oxygen and fluorine analyses to test the correction programs for light element radiation. It was found that their latest program with the "quadrilateral" absorption correction model was the best, and the authors concluded that their absorption correction was the best. We have some serious objections against both the procedure followed as well as the conclusions drawn. As far the "heavy element" file is concerned we can be brief: In this data base there is not much left to correct for, as a quick glance at the k-ratios and the concentrations in the file shows. This is the result of eliminating all heavy absorption cases. This conclusion is substantiated by the fact that 330 out of 554 analyses were suited to a test on the atomic number correction (absorption factor < 10%; atomic number correction).

54

Considering the use of the "light element" file our objections are more serious. It is suggested that the analysis of oxygen and fluorine present difficult cases of absorption which would be true in some cases if these elements could be measured relative to pure element standards. The use of complex standards, like Al_2O_3 and LiF, reduces the problem to a medium case of absorption which most modern correction programs should be able to deal with.

For example, at 30 kV the absorption factor for O-K α in Al₂O₃, relative to a pure oxygen standard, is approximately 3.6; that for O-K α in MoO₃ (one of the most difficult cases) is approximately 11.3; hence, it follows that the absorption factor shows an increase of only 3.14.

In many of the heavy absorption cases, which have been removed from the data file, the absorption factor ranges from 3 up to more than 12. Thus the real test cases for absorption are precisely those analyses that have been removed. A further objection concerns the use of non-conducting specimens such as oxides and fluorides for a comparative test. The influence of non-conductivity on the shape of the $\Phi(qz)$ curves is not even mentioned. The mere application of a conductive surface coating, with noticeable deleterious effects on the measurements themselves, does not change the intrinsic conductivity of a specimen; it only prevents surface charging.

In our opinion, however, it is inconceivable that an electron can start anything like a random walk in a "hostile" environment. There simply must be an additional driving force pushing it back, leading to a distortion of the $\Phi(\varrho z)$ curve. Needless to say that none of the existing correction programs take these phenomena into account.

However, as long as these problems have not been solved we will not use measurements on nonconducting specimens like the oxides and fluorides used by *Sewell* et al. The fact that all programs tested show a significant positive bias on these data may be taken as further evidence against their use. The fluorides may exhibit the additional problem of chemical instability under electron bombardment. A total lack of documentation on these measurements prevents any further comments on this issue.

Considering all the objections raised here we have decided to compose a new data base, partly based on more recent measurements.

5.2 The new data base

In composing the new data base a total number of 681 measurements were selected mainly on criteria of documentation, consistency and wide range of conditions applied.

Full details on the data base, including the mass absorption coefficients used, are given in Appendix 1.

The following analyses were selected:

Number	Reference
1- 16	Pouchou and Pichoir (1984)
17- 76	Willich (1983)
77–244	Heinrich et al. (1971)
245-292	Christ et al. (1982)
293-328	Colby (1968)
329-437	Thoma (1970)
438-472	Peisker (1967)
473-480	Springer (1966)
481-625	Bastin and Heijligers (1984)
626-681	Pouchou and Pichoir (1984)

Note (1) that many recent measurements performed on modern instruments have been included, and (2) that a relatively large number of heavy absorption cases have been (re)introduced, including the measurements by *Thoma* (1970) and *Pouchou* and *Pichoir* (1984).

In addition a compilation of 117 carbon analyses (*Bastin* and *Heijligers* 1984-3) have been used in the present test.

Finally, a number of oxygen analyses (*Willich* et al. 1985), performed on non-coated electrically conducting oxides were used to test the performance of our new program in these cases.

5.3 Results

A total number of 6 current correction programs were used. Apart from our own new version, henceforth designated by BAS851, these were three different versions of Love and Scott's programs, called LOS, LOSI and LOSII. The LOS and LOSI versions employ Bishop's rectangular model for absorption in which either the original (*Love* and *Scott* 1978) equation for the main input parameter \overline{qz} is used (LOS) or the new equation (*Sewell* et al. 1985), obtained by optimization (LOSI). In the LOSII version the latest so-called "quadrilateral" model is used. In all LOS versions the same atomic number correction is used (*Love* and *Scott* 1980). For details concerning the other two programs, ZAF (commercially obtained from Tracor Northern) and that by RUSTE, the reader is referred to our previous papers.

We have previously noted that our $\Phi(\varrho z)$ program performed less satisfactory for low overvoltage ratios and this suspicion was confirmed in the present test. The equation for α is no longer reliable for low overvoltages. The largest deviations were always found for high-energy radiations in heavy matrices, e.g. Cu-K α in Au. For U_o > 1.5 the performance was quite satisfactory. We, therefore, decided, to make a restriction and only admit analyses at U_o > 1.5; which was found beneficial for all programs tested. The total number of analyses actually used in the test was thereby reduced to 627.

In Figs. 6a-6f the results obtained with the 6 programs for the large database have been represented in the form of histograms. In Table 1 the averages and r.m.s. values are given.

Table 1 Relative root-mean-square values* (%) and averages* for various programs; 627 analyses, $U_0>1.5$

		-
Program	r.m.s.(%)	Average
BAS 851	2.99	1.0012
LOS	5.05	1.0016
LOSI	5.45	1.0016
LOSII	4.33	0.9904
ZAF	6.13	1.0196
RUSTE	8.15	1.0313

* These apply to the ratio between the calculated and the measured k-ratios.

The figures speak for themselves. One should not jump to premature conclusions, however, because too much depends on the choice of the mass absorption coefficients. As long as these are not known with an accuracy of, say 1%, definite statements on the performance of a particular absorption correction model cannot be made.

Simple and rudimentary models like Bishop's square model can never deal with heavy cases of absorption. This is evident in Figs. 6b and 6c where a long tail is developed, mainly caused by the Al-K α and Si-K α measurements by *Thoma* (1970). Such a tail

becomes even more pronounced in the ZAF and RUSTE models and confirms the expectations based on earlier experiences with these models.

The LOSI version is not necessarily an improvement over the original LOS version (cf Figs. 6c and 6b) and the LOSII version, based on the quadrilateral model, does not give a dramatic improvement over the original LOS version. The parameters for the LOSII version have been optimized with different mass absorption coefficients for the cases of heaviest absorption (Al-K α , Si-K α). The results would improve with their choice of mass absorption coefficients, but at the expense of the performance of the other two versions which would rapidly deteriorate.

The detailed results for two cases of heavy absorption are represented in Figs. 7a and 7b, together with the mass absorption coefficients used in this test. It must be mentioned that, if *Henke* et al.'s (1982) mass absorption coefficients had been used, as was done by *Sewell* et al. (1985), then all calculated k-ratios would have been higher: in some cases (e.g. Al-K α in Ni) up to 10% higher. This shows again the importance of the mass absorption coefficients.

The results for the 117 carbon analyses, relative to Fe_3C as a standard, have been represented in Fig. 8 and Table 2. The mass absorption coefficients used in this test are the values proposed by *Bastin* et al. (1984–3, 1986). It must be emphasised that these values produced improvements for all the programs tested. This was further corroborated by the findings of *Willich* (1985) who tested the *Pouchou* and *Pichoir* (1984) model on some of our carbon measurements. Considering the results of the present comparison in Fig. 8 and Table 2 we can again say that the histograms show the value of the present method.

Moreover, it would appear again that the LOSI version is not necessarily an improvement over the original LOS version and that the performance of the LOSII version is somewhat disappointing, regarding the claim that has been made (Sewell et al. 1985) for light element analysis. The worst performance of the three LOS programs was observed in heavy matrices, like TaC, WC and W₂C (Figs. 9a and 9b), where very large deviations were found. In those and similar cases it is not only a matter of the absorption correction model, for which the parameterization is apparently unsatisfactory; but also the atomic number correction behaves in a most peculiar way - an effect which has been noticed earlier already (Bastin et al. 1984-2). After an initial very slow increase of the Z-factor for carbon up to 12 keV, an ever increasing acceleration takes place which is partially compensated by the absorption factor which goes through a maximum at 25 keV and then decreases again.

56

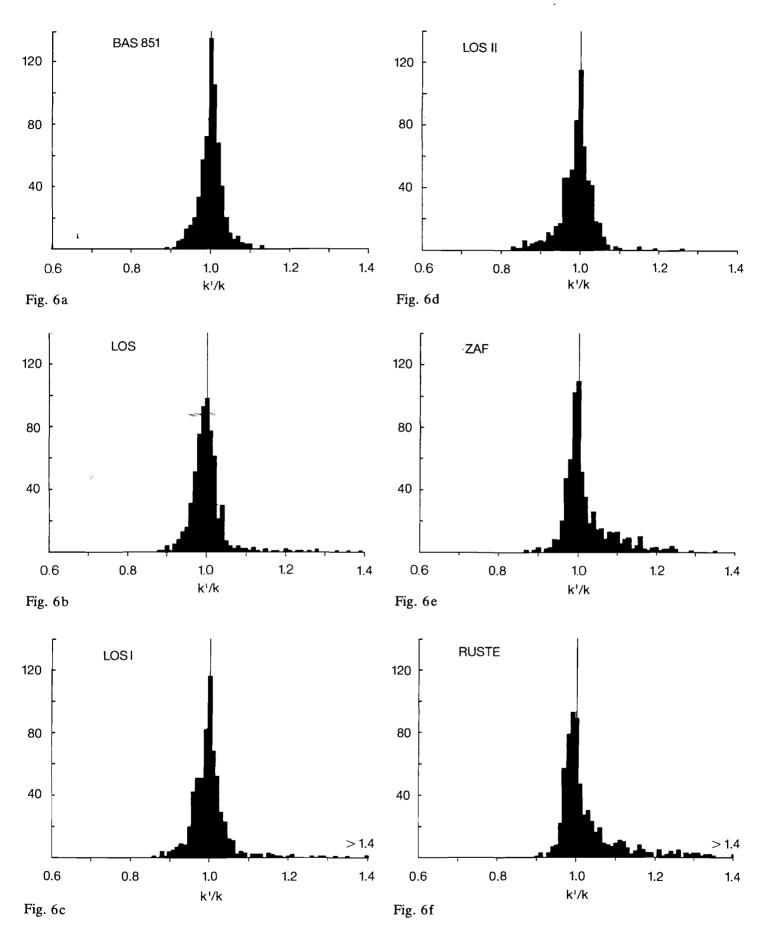
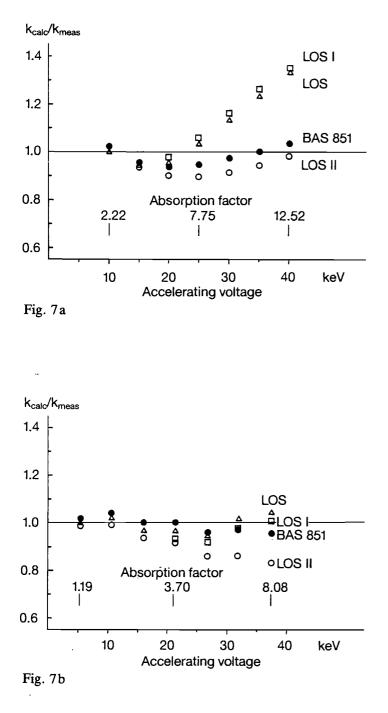
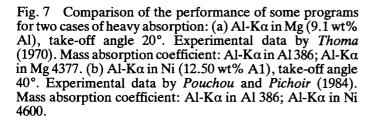


Fig. 6 Histograms representing the results for 6 correction programs tested on 627 analyses (overvoltage ratio > 1.5). k' is the calculated and k the measured intensity ratio.

SCANNING Vol. 8, 2 (1986)





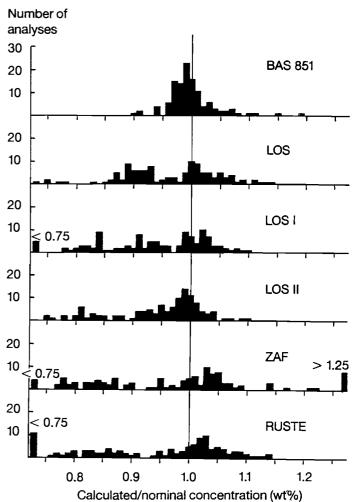


Fig. 8 Performance of various programs for the analysis of carbon in 13 binary carbides. 117 analyses, relative to Fe_3C , between 4 and 30 keV. Integral intensity measurements.

Table 2 Relative root-mean-square values* (%) and averages* for various programs; 117 Carbon Analyses, rel. to Fe₃C, 4-30 keV; Integral intensity measurements

Program	r.m.s.(%)	Average
BAS 851	4.11	0.999
LOS	8.33	0.964
LOSI	9.60	0.936
LOSII	7.78	0.948
ZAF	17.86	0.989
RUSTE	11.94	0.946

* Note that this time these apply to the ratio between the calculated and the nominal concentration in wt%.

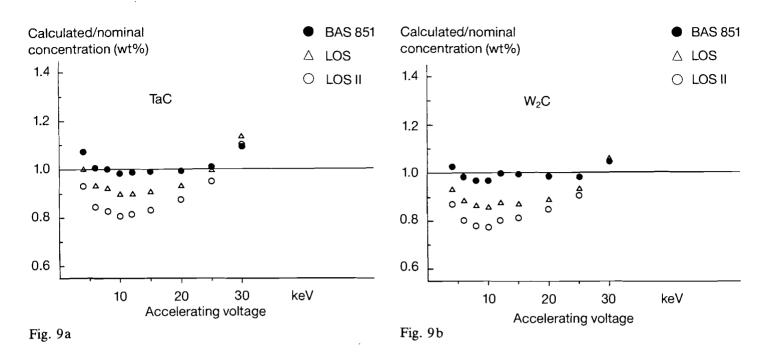


Fig. 9 Results for the analysis of carbon in two heavy-metal carbides as a function of accelerating voltage: (a) C-K α in TaC, take-off angle 40°. Standard Fe₃C. Integral intensity measurements. Mass absorption coefficient: C-K α in C 2373, C-K α in Fe 13500, C-K α in Ta 16000. (b)-G-K α in W₂C. Mass absorption coefficient: C-K α in W 17000.

Finally, our new version was tested on a number of oxygen analyses (*Willich* et al. 1985). It is very important to note that these analyses were performed on non-coated electrically conductive oxides.

58

Table 3 Results of the BAS851 program for oxygen analyses. Non-coated, electrically conductive specimens. Standard $Y_3Fe_5O_{12}^*$

Sample	Comp. (wt%)	Acc.Volt. (keV)	k _{meas}	k _{calc}	devia- tion (%)
	Ba 12.7	5	1.257	1.247	- 0.8
BaFe ₁₂ O ₁₀	Fe 59.8	7.5	1.433	1.443	+ 0.7
	Ga 0.2	10	1.647	1.661	+ 0.9
	O 27.3	12.5	1.841	1.879	+ 2.1
		5	1.117	1.085	- 2.9
PbFe ₁₂ O ₁₉	Pb 21.0	7.5	1.197	1.175	- 1.8
	Fe 54.0	10	1.278	1.267	- 0.8
	O 25.0	12.5	1.361	1.350	- 0.8
		5	0.694	0.714	+ 2.9
RuO ₂	Ru 76.0	7.5	0.576	0.590	+ 2.4
	O 24.0	10	0.498	0.513	+ 3.0
		12.5	0.459	0.467	+ 1.8

* Composition (wt%): Y 35.8, Fe 37.5, Si 0.2, Pb 0.7, O 25.8.

Given the success of both our previous as well as the new correction program for the analysis of carbon, considering the wide range of accelerating voltages applied, they should be expected to work equally well or even better for oxygen. Table 3 clearly demonstrates that this is the case. The results shown are those of the new version, which are virtually identical to those of the previous version (mass absorption coefficients of *Henke* et al. 1982).

We conclude that the calculated k-ratios agree very well with the measured ones within the experimental error, and that our new version also works well for oxygen. This substantiates the doubts we expressed earlier about measurements on coated, non-conductive specimens.

6. Discussion

We believe that we have shown that our new program is probably among the best currently available. However, caution has to be exercised in making too definite statements, because too much depends on uncertain input parameters like mass absorption coefficients. The vast majority of experimental $\Phi(\varrho z)$ data have been obtained using *Heinrich's* (1966) mass absorption coefficients. Hence, it follows that when $\Phi(\varrho z)$ equations are fitted to these $\Phi(\varrho z)$ data, the resulting correction program will perform best with this set of mass absorption coefficients or a similar one like that of *Frazer* (1967). If it should become apparent in the future that the new values of *Henke* et al. (1982) are indeed an improvement, then all existing $\Phi(\varrho z)$ data would have to be corrected and, as a consequence, our $\Phi(\varrho z)$ equations would have to be refitted.

In both cases, however, the same curve of *emitted* intensity vs. mass depth, which is the *measured* quantity in experimental $\Phi(\varrho z)$ measurements, should be obtained. It is obvious, therefore, that under no circumstances can a particular absorption correction model operate with a variety of mass absorption coefficients for a specific case: the better the model is, the more selective it will be for the mass absorption coefficients.

We have not made any effort to compare items like the atomic number correction employed in the various programs because

(a) the reported differences, typically of the order of 0.5% (or less) in the r.m.s. values, are much too small to be very concerned with and it would require a data base of extremely accurate measurements to make statements of any value;

(b) the largest atomic number effects usually go with heavy absorption effects (e.g. Al-K α , Si-K α , O-K α radiations in heavy matrices) and this makes a separate test on the atomic number correction extremely difficult.

We consider the separation into atomic number and absorption effects artificial because the important physical quantity is the emitted intensity, which is represented by the combined Z and A factors. It is also possible that the malfunctioning of the atomic number correction is to a certain extent compensated by a malfunctioning of the absorption correction and the program in question may still turn out very good answers.

It appears more interesting to discuss the absorption correction models, especially the new "quadrilateral" model recently introduced (*Sewell* et al. 1985). It should provide an obvious improvement over the earlier models used by Love and Scott, simply because a slow evolution has taken place from a totally unrealistic rectangular model to a quadrilateral model which starts to look like a rudimentary $\Phi(\varrho z)$ curve. The absorption correction of this model is based on 4 parameters (see Fig. 10): $\overline{\varrho z}$ (the mean depth of x-ray production), ϱz_m (the position of the maximum in the

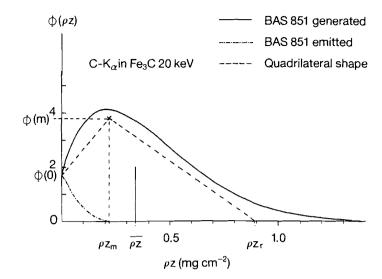


Fig. 10 Comparison between the $\Phi(\varrho z)$ curve for C-K α in Fe₃C at 20 keV generated by our present version (BAS851) and the quadrilateral model (*Sewell* et al. 1985). Emitted intensity according to BAS851, assuming mass absorption coefficient: C-K α in C 2373; C-K α in Fe 13500. Take-off angle 40°.

" $\Phi(\varrho z)$ " curve), h (the ratio between $\Phi(m)$ and $\Phi(0)$) and ϱz_r (the fictitious end of the $\Phi(\varrho z)$ curve).

The parameter $\overline{0z}$ is considered (*Sewell* et al. 1985) the dominant factor in the absorption correction, even to the extent that the ranking order of different models was judged to follow closely the averaged error in calculated-to-measured $\overline{02}$ values. It has further been argued on several occasions by these authors that it is not necessary to have the real $\Phi(\rho z)$ curve for an accurate absorption correction. Although this may apply to cases of light to medium absorption, such a statement does not become true by repeating it. This can clearly be seen in Fig. 10 where the quadrilateral shape is compared to the $\Phi(\rho z)$ curve generated by our program for the case of C-Ka radiation in Fe₃C at 20 keV. It is difficult to see how a parameter like \overline{oz} , which is located far beyond the point from where the last photon is able to reach the surface, can dominate the absorption correction. It is evident, in our opinion, that in this case the first part of the curved $\Phi(oz)$ curve, roughly up to the maximum, is the sole determining factor – that is, the shape factor is dominant for cases of heavy absorption, a view which has been put forward by Bishop (1974) already. Anyway, it seems difficult to us for any artificial model to find the correct parameterization, especially where parameters like ρz_r , without any physical significance, are involved.

A few final remarks on the quadrilateral model have to be made concerning the computational complexity. It has been suggested (*Sewell* et al. 1985) that parameters like ϱz_m and ϱz_r are expressed in terms of the mean depth $\overline{\varrho z}$.

This is true for ϱz_m ; for ϱz_r , however, it is the other way around: ϱz is expressed in quadratic terms of ϱz_m and ϱz_r , which means that ϱz_r has to be solved as one of the roots of a quadratic equation. It is obvious that this further contributes to the considerable complexity already present in this new model. One could wonder if all this effort would not be better spent in trying to find the real $\Phi(\varrho z)$ curve.

7. Conclusions

(1) The new version of our correction program, based on improved equations for the Gaussian $\Phi(\varrho z)$ approach, is probably among the best of the currently available correction programs, provided that the proper mass absorption coefficients are used. Its performance is excellent both for medium to heavy elements (r.m.s. value 2.99%) as for very light elements like carbon (r.m.s. value 4.1%). In both cases it must be taken into account that due to the presence of very heavy absorption cases the experimental error is correspondingly larger, which makes the results all the more remarkable.

(2) The new correction program by Sewell et al., based on the quadrilateral absorption model, will perform rather well for medium to heavy elements, provided that the authors' choice of mass absorption coefficients is followed. The performance for very light elements like carbon is much less satisfactory. A new optimization using heavy absorption cases, might produce an improvement.

(3) The Love and Scott versions based on the rectangular absorption model cannot be recommended for cases of significant absorption.

(4) The ZAF and Ruste models are the least satisfactory of the models evaluated here.

References

- Bastin G F, van Loo F J J, Heijligers H J M: An evaluation of the use of Gaussian $\Phi(\varrho z)$ curves in quantitative electron probe microanalysis. A new optimization. X-ray Spectr 13, 91-97 (1984-1)
- Bastin G F, Heijligers H J M, van Loo F J J: The performance of the modified $\Phi(\varrho z)$ approach as compared to

the Love and Scott, Ruste and Standard ZAF correction procedures in quantitative electron probe microanalysis. Scanning 6, 58-68 (1984-2)

- Bastin G F, Heijligers H J M: Quantitative electron probe microanalysis of carbon in binary carbides. Report Eindhoven Univ of Techn, the Netherlands, pp 90-94, ISBN 90-6819-002-4 (1984-3)
- Bastin G F, Heijligers H J M: Quantitative electron probe microanalysis of carbon in binary carbides, Part I and II, X-ray Spectr, to be published (1986)
- Beaman D R, Isasi J A: Electron Beam Microanalysis. ASTM Spec Techn Publ 506 (1972)
- Bishop H E: The prospects for an improved absorption correction in electron probe microanalysis. J Phys D 7, 2009-2020 (1974)
- Brown J D, Parobek J L: X-ray production as a function of depth for low electron energies. X-ray Spectr 5, 36-40 (1976)
- Brown J D, Packwood R H: Quantitative electron probe microanalysis using Gaussian $\Phi(\varrho z)$ curves. X-ray Spectr 11, 187–193 (1982)
- Castaing R, Descamps J: On the pysical basis of point analysis by x-ray spectography. J de Physique et le Radium 16, 304-317 (1955)
- Castaing R, Hénoc J: Répartition en profondeur du rayonnement caractéristique. X-ray Optics and Microanalysis (R Castaing, P Deschamps, J Philibert, Eds) Hermann, Paris 1966, pp 120-126
- Christ B, Oelgart G, Stegmann R: ZAF correction for electron probe microanalysis of Bi_{1-x}Sb_x alloys. Phys Stat Solidi (a) 71, 463-471 (1982)
- Colby J W, cited by Poole D M in: Progress in the Correction for the Atomic Number Effect. Quantitative Electron Probe Microanalysis (K F J Heinrich, Ed) NBS Spec Publ (Washington, US Dept of Commerce) 298, 93-131 (1968)
- Frazer J Z: A computer fit to mass absorption coefficient data. Inst for the Study of Matter, Univ of California, La Jolla, California, 1967, SIO Ref, pp 67-29
- Heinrich K F J: X-ray Absorption Uncertainty. In: The Electron Microprobe (T D Mckinley, K F J Heinrich, D B Wittry, Eds) John Wiley & Sons, New York, 1966 pp 296-377
- Heinrich K F J, Myklebust R C, Rasberry S D, Michaelis R E: Preparation and Evaluation of SRM's (standard reference materials) 481 and 482, gold-silver and goldcopper alloys for microanalysis, NBS Spec Publ Washington 1971, US Dept of Commerce, No 260-28
- Henke B L, Lee P, Tanaka T J, Shimabukuro R L, Fujikawa B K: Low-energy x-ray interaction coefficients: Photoabsorption, Scattering and Reflection. Atom Data and Nucl Data Tables, 27, 1-144 (1982)
- Love G, Cox M G, Scott V D: Assessment of Philibert's absorption correction models in electron-probe microanalysis. J Phys D 8, 1686-1702 (1975)
- Love G, Cox M G, Scott V D: The surface ionisation function $\Phi(0)$ derived using a Monte Carlo method. J Phys D 11, 23-31 (1978)

SCANNING Vol. 8, 2 (1986)

- Love G, Scott VD: Evaluation of a new correction procedure for quantitative electron probe microanalysis. J Phys D 11, 1369–1376 (1978)
- Love G, Scott VD: A critical appraisal of some recent correction procedures for quantitative electron-probe microanalysis. J Phys D 13, 995-1004 (1980)
- Packwood R H, Brown J D: A Gaussian expression to describe $\Phi(\varrho z)$ curves for quantitative electron-probe microanalysis. X-ray Spectr 10, 138-146 (1981)
- Parobek L, Brown J D: The atomic number and absorption corrections in electron microprobe analysis. X-ray Spectr 7, 26-30 (1978)
- Peissker E: Comparison of various correction methods for quantitative electron beam microanalysis. Mikrochim Acta, Suppl II, 156-172 (1967)
- Philibert J: A method for calculating the absorption correction in electron probe microanalysis. 3rd Int Symp on X-ray Optics and X-ray Microanalysis, Stanford (1962) (Eds H H Pattee, V E Cosslett and E Engström), Academic Press, New York 1963, pp 379-392
- Pouchou J L, Pichoir F: A new model for quantitative x-ray microanalysis. Part I: Applications to the analysis of homogeneous samples. Réch Aérospat 1984-3, 13-38 (1984)
- Pouchou J L, Pichoir F: Personal Communication (1985)
- Ruste J, Zeller C: Correction d'absorption en microanalyse. C R Acad Sci, Paris T284, Série B, 507-510 (1977)
- Ruste J: Principes généraux de la microanalyse quantitative appliquée aux éléments très légers. J Microsc Spectr Electron 4, 123-136 (1979)
- Scott VD, Love G: Quantitative Electron Probe Microanalysis (Eds VD Scott, G Love), Ellis Horwood Publ, Chichester UK 1983, p 175
- Sewell D A, Love G, Scott V D: Universal correction procedure for electron-probe microanalysis. J Phys D 18, 1233-1280 (1985)
- Shinoda G: Some topics in recent development of electron probe microanalysis in Japan. X-ray Optics and Microanalysis (Eds R Castaing, P Deschamps, J Philibert). Hermann, Paris 1966, pp 97-111
- Springer G: Determination of the atomic number effect on some minerals, Optique des Rayons X et Microanalyse (Eds R Castaing, P Deschamps, J Philibert) Hermann. Paris 1966, pp 296-304

- Thoma C: Testing of correction procedures for absorption, atomic number and secondary fluorescence by variation of the accelerating voltage and take-off angles. Mikrochim Acta, Suppl IV, 102–113 (1970)
- Willich P: Personal Communication (1983)
- Willich P: Electron Probe Microanalysis of Submicron Layers using depth distribution functions. J Microsc Spectr Electron to be published
- Willich P, Obertop D, Tolle H J: Quantitative electron microprobe determination of oxygen in metal layers covered by surface oxide films. X-ray Spectr 14, 84-88 (1985)

Appendix

Numerial details on the data base used in the comparison of the performances of various correction programs. 681 binary systems AB.

- Column 1: Analysis number
- Column 2: Atomic number of component A
- Column 3: Atomic number of component B
- Column 4: Mass absorption coefficient element of A-radiation in element A
- Column 5: Mass absorption coefficient of element A-radiation in element B
- Column 6: Critical excitation voltage (keV) element A-radiation
- Column 7: Weight fraction of element A
- Column 8: k-ratio of element A-radiation
- Column 9: Accelerating voltage (keV)
- Column 10: Take-off angle (deg)
- Column 11: Type of element A-radiation; $0=K\alpha$, $1=L\alpha$, $2=M\alpha$

Appendix

.....

	79	29	1070	2150	7 770					
	79	29	1070		2,220	0.5080	0.4259	5,20	40,00	2
	79		-	2150	2,220	0.5080	0.4203	10.40	40.00	2
		29	1070	2150	2.220	0.5080	0.4034	15,70	40,00	2
	79	29	1070	2150	2,220	0.5080	0.3865	20.80	40.00	- 2
	79	27	1070	2150	2.220	0.5080	0,3668	26.10	40.00	2
	79	29	1070	2150	2,220	0,5080	0.3499	31.50	40.00	2
	79	27	1070	2150	2.220	0,5080	0+3405	36.60	40.00	2
	79	29	1070	2150	2,220	0.5080	0.3349	39.70	40.00	2
	79	29	1070	2150	2.220	0,3000	0.2317	5.20	40.00	2
10	79	29	1070	2150	2,220	0.3000	0.2317	10.40	40,00	2
	79	29	1070	2150	2,220	0,3000	0.2186	15,70	40.00	2
	79	29	1070	2150	2,220	0.3000	0.2054	20.80	40,00	2
	79	29	1070	2150	2,220	0.3000	0,1886	26.10	40.00	2
	79	29	1070	2150	2,220	0.3000	0.1773	31.50	40.00	2
	79	29	1070	2150	2.220	0.3000	0.1717	36.60	40.00	2
	79	29	1070	2150	2,220	0.3000	0.1687	39.70	40.00	2
	79	29	130	246	11,920	0.8020	0.7620	25.00	40,00	1
	79	29	130	246	11,920	0.8020	0.7610	20.00	40,00	ī
	79	27	130	246	11,920	0,8020	0,7510	16.00	40.00	1
20	29	79	54	210	8,780	0.1980	0.2350	25.00	40.00	Ō
	29	79	54	210	8.780	0.1980	0.2450	20.00	40,00	ŏ
	27	79	54	210	8,780	0.1780	0.2520	16.00		
	79	29	130	246	11.720	0.6040	0.5370	25.00	40.00	0 1
	79	29	130	246	11.920	0.6040	0.5300	20.00	40.00	-
	79	29	130	246	11.920	0.6040	0.5180		40.00	1
	29	79	54	210	8.780	0.3760	0.4470	16.00 25.00	40.00	1
	29	79	54	210	8.980	0,3760	0.4630		40.00	0
	29	79	54	210	8.780	0,3760		20.00	40.00	0
	79	29	130	246	11.720	0.4010	0.4720	16.00	40.00	0
30 -	. 79	29	130	246	11.920	0.4010	0,3380	25,00	40.00	1
50	79	29	130	246			0.3340	20.00	40.00	.1
	29	27 79	54	240	11.920	0,4010	0.3230	16.00	40.00	1
	29	79	54	210	8,780	0,5990	0.6430	25.00	40.00	0
	29	79	54			0.5990	0.6550	20,00	40,00	0
	.×.7 79			210	8.980	0.5990	0.6700	16.00	40.00	0
	79	29 29	130 130	246	11.920	0.2010	0.1550	25.00	40.00	1
	79			246	11.920	0,2010	0.1530	20.00	40.00	1
		29	130	246	11.920	0.2010	0.1470	16.00	40.00	1
	29 29	79 79	54	210	8,780	0.7970	0.8270	25.00	40.00	0
			54	210	8,980	0.7990	0,8350	20.00	40.00	0
40	29	79	54	210	8,980	0.7990	0.8450	16.00	40.00	0
	79 79	29 29	1070	2150	2.220	0.8020	0.7420	14.00	40.00	2
	79		1070	2150	2.220	0,8020	0.7450	12.00	40,00	2
	29	29	1070	2150	2,220	0.8020	0.7560	10.00	40.00	2
	29	79 79	54 54	210	8,780	0.1980	0,2570	14.00	40,00	0
	27 79			210	8.780	0,1980	0.2640	12.00	40.00	0
	79 79	29	1070	2150	2.220	0,6040	0,5110	14.00	40.00	2
	79 79	29	1070	2150	2,220	0.6040	0.5140	12.00	40,00	2
		29	1070	2150	2,220	0,6040	0.5230	10.00	40.00	2
	29	79	54	210	8,780	0.3760	0.4760	14.00	40.00	0
50	29	79	54	210	8,980	0.3960	0,4940	12.00	40.00	0
	79	29	1070	2150	2,220	0,4010	0.3140	14.00	40.00	2
	79	27	1070	2150	2,220	0,4010	0.3160	12.00	40.00	2
	79	27	1070	2150	2,220	0.4010	0.3220	12.00	40.00	2
	29	79	54	210	8.780	0,5990	0.6750	14.00	40.00	0
	29	79	54	210	8.780	0.5990	0.6940	12.00	40.00	0
	79	27	1070	2150	2.220	0.2010	0.1430	14.00	40,00	2
	79	29	1070	2150	2.220	0,2010	0.1470	12.00	40.00	2
	79	27	1070	2150	2,220	0.2010	0.1470	12.00	40.00	2
60	29	79	54	210	8,780	0.7970	0.8450	14.00	40.00	0
6 0	29	79	54	210	8,780	0.7990	0.8530	12.00	40,00	0

	29	29	1070	2150	2.220	0+8050	0.7640	5.00	40.00	2	
	79	29	1070	2150	2.220	0,8020	0,7670	7.50	40.00	2	
	79	29	1070	2150	2.220	0.6040	0.5330	5.00	40.00	2	
•	79	29	1070	2150	2,220	0+6040	0.5330	2.50	40.00	2	
	29	27	1070	2150	2.220	0.4010	0.3340	5,00	40.00	2	
	79 79	29 29	1070	2150	2.220	0.4010	0.3300	7,50	40.00	2	
	79	29	1070 1070	2150	2.220	0.2010	0.1580	5.00	40.00	2	
	27	79	1929	2150 5790	2,220	0.2010 0.1980	0,1570	2.50	40.00	2	
70	29	79	1828	5790	0.933	0.1980	0,2130 0,1850	5.00 7.50	40.00	1	
	29	79	1928	5790	0,733	0.3960	0.4270	5,00	40.00 40.00	1 1	
	27	- 79	1928	5790	0.933	0.3960	0.3780	7,50	40.00	1	
	29	,79	1828	5790	0.933	0.5990	0,6290	3.00	40.00	î	
	27	79	1828	5790	0.933	0.5990	0.5800	7.50	40.00	ĩ	
	29	29	1828	5790	0,933	0.7990	0,8190	5.00	40.00	1	
	29	79	1028	5790	0,933	0.7990	0,7850	7.50	40.00	1	
	29 29	47 47	130	130	11,920	0.2243	0.2030	15,00	52.50	1	
	79	47	130	130	11.920	0.2243	0.2030	20.00	52,50	1	
80	79	47	130 130	130 130	11.920	0.2243	0.2110	30.00	52.50	1	
90	79	47	130	130	11,920	0.2243	0.2160	40.00	52.50	1	
	79	47	130	130	11,920	0,4003	0.2140 0.3680	48.50	52,50	1	
	79	47	130	130	11.720	0.4003	0,3660	15.00 20.00	52,50 52,50	1 1	
	79	47	130	130	11.920	0.4003	0.3760	30,00	52.50	1	
	79	47	130	130	11.920	0.4003	0,3840	40.00	52,50	ĩ	
	79	47	1.30	130	11.920	0,4003	0,3850	48.50	52,50	1	
	79	47	130	130	11.720	0.6005	0,5660	15.00	52.50	1	
	79 79	₹47 47	130	130	11.920	0.6005	0.5730	20.00	52.50	1	
90	79	47	130 130	130 130	11,920 11,920	0,3005	0.5800	30.00	52.50	1	
50	79	47	130	130	11.720	0.6005 0.6005	0,5840	40.00	52.50	1	
	79	47	130	130	11.720	0,8005	0,5840 0,7890	48,50	52,50	1	
	79	47	130	130	11.920	0.8005	0.7830	15.00 20.00	52,50	1	
	29	47	130	130	11.920	0,8005	0.7830	30.00	52.50 52.50	1 1	
	79	47	130	130	11.720	0.8005	0.7900	40.00	52.50	1	
	79	47	130	130	11.920	0.8005	0.7880	48.50	52.50	i	
	79	47	1070	1300	2.220	0.2243	0,2010	10.00	52.50	2	
	79	47	1070	1300	2.220	Ò-2243	0.1970	20.00	52.50	2	
100	79 79	47 47	1070	1300	2,220	0.2243	0.1720	30.00	52.50	2	
100	79	47	1070 1070	1300 1300	2.220 2.220	0.2243	0.1850	40.00	52.50	2	
	79	47	1070	1300	2.220	0,2243 0,4003	0.1810 0.3620	48,50 10,00	52,50	2	,
	79	47	1070	1300	2.220	0.4003	0.3640	20,00	52.50 52.50	2 2	
	79	47	1070	1300	2.220	0.4003	0,3510	30.00	52.50	2	
	79	47	1070	1300	2.220	0.4003	0,3440	40.00	52:50	2	
	79	47	1070	1300	2.220	0,4003	0.3370	48.50	52.50	2	
	79	47	1070	1300	2.220	0.6005	0.5590	10.00	52.50	2	
	29	47	1070	1300	2,220	0.6005	0,5510	20.00	52.50	2	
	79	47	1070	1300	2.220	0.6005	0.5470	30.00	52,50	2	
110	79 79	47 47	1070	1300	2.220	0.6005	0.5410	40.00	52.50	2	
	79	47	1070 1070	1300 1300	2.220	0.6005	0.5370	48.50	52.50	2	
	79	47	1070	1300	2,220 2,220	0.8005 0.8005	0.7710	10.00	52.50	2	
	79	47	1070	1300	2,220	0.8005	0.7640 0.7660	20.00	52.50	2 2	
	79	47	1070	1300	2,220	0.8005	0.7610	30+00 40+00	52.50 52.50	2	
	79	47	1070	1300	2,220	0.8005	0.7550	48.50	52.50	2	
	47	79	522	1959	3.352	0.1996	0.2230	5.00	52.50	Ť	
	47	79	522	1959	3,352	0.1996	0,1910	10.00	52.50	1	
100	47	79	522	1959	3.352	0,1996	0.1440	20.00	52.50	1	
120	47	79	522	1959	3,352	0.1996	0,1090	30,00	52.50	t	

SCANNING Vol. 8, 2 (1986)

G. F. Bastin et al.: Improvement in the Gaussian $\Phi(\varrho z)$ approach for matrix correction

62

а

SCANNING Vol. 8, 2
(1986)

		47	79	522	1759	3.352	0.1996	0.0887	40.00	52.50	1		29	79	1828	5790	0.933	0.3964	0.2190	25.00	52.50	
		47	79	522	1959	3.352	0.1996	0.0795	48.50	52.50	1		29	79	1828	5790	0.933					
		47	79	522	1959	3.352	0.3992	0.4360	5.00	52.50	Ĩ.		29	79				0.3964	0.2000	30.00	52.50	
		47	79	522	1959	3.352	0.3992								1828	5790	0.733	0+3964	0.1660	40.00	52,50	
								0.3860	10.00	52.50	1		29	79	1828	5790	0.933	0.3964	0.1610	40.50	52.50	
		47	79	522	1959	3.352	0.3992	0,3090	20.00	52,50	1		29	79	1028	5790	0.933	0.5792	0.5570	10.00	52.50	
		47	79	522	1959	3.352	0.3992	0.2450	30.00	52.50	1.		29	79	1828	5790	0.933	0.5792	0.5240	12.00		
		47	79	522	1959	3.352	0.3992	0.2080	40.00	52.50	1			79							52.50	
		47	79	522	1959	3.352	0.3992	0,1810	48.50	- 52.50	1		29		1828	5790	0.933	0,5992	0.4840	15.00	52.50	
		47	79										27	79	1828	5790	0.933	0.5772	0.4280	20.00	52.50	
				522	1959	3,352	0.5993	0.6240	5.00	52.50	1		29	79	1828	5790	0,933	0.5992	0.3870	25.00	53.50	
	130	47	79	522	1959	3,352	0.5993	0.5840	10.00	52.50	1	190	29	79	1929	5790	0.933	0.5992	0.3600	30.00	52.50	
		47	79	522	1959	3.352	0,5993	0.5040	20.00	52,50	1		29	79	1829	5790	0.933	0.5992	0.3130	40.00		
		47	79	522	1959	3,352	0.5993	0.4260	30.00	52.50	1		29	79	1828	5790	0.933				52,50	
		47	79	522	1959	3.352	0.5993	0.3750	40.00	52.50	1							0,5992	0.3040	48.50	52,50	
		47	79	522	1959	3.352	0.5993	0.3390	48.50	52.50			29	79	1828	5790	0,933	0,7985	0.7640	10.00	52.50	
		47	79		1959						1		27	79	1828	5790	0.733	0.7985	0.7470	12.00	52.50	
				522		3.352	0.7758	0,8070	5.00	52,50	1		29	79	1828	5790	0.933	0.7985	0.7160	15.00	52.50	
		47	79	522	1959	3,352	0,7758	0,7640	10.00	52.50	1		29	79	1828	5790	0.933	0.7985	0.6720	20.00	52,50	
		47	79	522	1959	3.352	0.7758	0,7060	20.00	52,50	1		29	79	1828	5790	0.933	0.7985	0.6320			
		47	79	522	1959	3,352	0.7758	0.6360	30.00	52,50	1		29	79	1020	5790				25.00	52.50	
		47	79	522	1959	3.352	0.7758	0.5860	40.00	52,50	1						0.933	0,7985	0.6020	30.00	52.50	
	140	47	79	522	1959		0.7758						29	79	1828	5790	0.933	0.7985	0.5500	40,00	52.50	
	140					3,352		0.5420	48.50	52.50	.1.	200	29	79	1828	5790	0.933	0,7985	0.5440	48.50	52.50	
		29	79	54	210	8,980	0.1983	0.2730	12.00	52.50	0		79	29	130	246	11.920	0.2012	0.1450	15.00	52.50	
^		29	79	54	210	8,980	0,1983	0.2540	15.00	52,50	0		79	27	130	246	11.920	0.2012	0.1580	20.00		
3		29	79	54	210	8,780	0.1983	0.2470	20.00	52,50	0		29	29	130						52,50	
1		29	79	54	210	8,980	0,1983	0.2400	25.00	52.50	ŏ					246	11.920	0.2012	0,1540	25.00	52.50	
>		29	79	54	210	8,980	0,1983	0.2350	30,00		ŏ		.79	29	130	246	11.920	0.2012	0.1570	30.00	52+50	
7										52.50			79	29	130	246	11.920	0.2012	0.1640	40.00	52,50	
7		29	79	54	210	8.980	0.1983	0.2180	40.00	52.50	0		29	29	130	246	11.920	0.2012	0.1520	48.50	52,50	
-		29	79	54	210	8.780	0.1983	0.2180	48.50	52.50	0		79	29	130	246	11.920	0.4010	0.3120	15.00	52.50	
1		27	79	54	210	8,980	0.3964	0.5000	12.00	52.50	0		29	22	130	246	11.920	0.4010	0.3330	20.00	52.50	
1		29	79	54	210	8.780	0.3964	0.4800	15.00	52.50	0		79	29	130	246	11.920	0.4010	0.3310	25,00	52.50	
2	150	29	79	54	210	8.980	0.3964	0.4640	20.00	52.50	0	210	29	29	130	246	11,920					
4		29	79	54	210	8.980	0.3964	0.4530	25.00	52.50	ō	210						0.4010	0.3310	30.00	52.50	
7		29	79	54	210	8,780	0.3964	0.4430	30.00	52,50	-		79	29	130	246	11.920	0.4010	0.3500	40.00	52,50	
-		29	7.9								0		79	29	130	246	11.920	0.4010	0.3260	48,50	52,50	
_				54	210	8,980	0.3964	0.4160	40,00	52,50	0		79	29	130	246	11.920	0.6036	0.5110	15,00	52.50	
0		29	79	54	210	8,980	0.3964	0,4140	48+50	52.50	0		79	29	130	246	11,920	0.6036	0.5310	20.00	52,50	
		29	79	54	210	8,780	0.5992	0.6780	12,00	52.50	0		29	29	130	246	11.920	0.6036	0.5290	25.00		
J		29	79	54	210	8,980	0.5992	0.6760	15.00	52.50	0		79	29	130	246	11.920	0.6036			52.50	
2		29	79	54	210	8,780	0.5992	0.6630	20.00	52.50	ō								0.5330	30.00	52.50	
5		29	79	54	210	8.980	0.5992	0.6510	25.00		ŏ		79	22	130	246	11.920	0.6036	0.5520	40.00	52,50	
ถึ เ		29	79	54	210	8.980	0.5992			52.50			79	29	130	246	11,920	0.6036	0.5210	48.50	52,50	
Ň.	160							0.6440	30.00	52.50	0		79	29	130	246	11,920	0.8015	0.7400	15.00	52.50	
	160	29	79	54	210	8,980	0.5992	0.6160	40.00	52.50	0	220	79	29	130	246	11.920	0.8015	0.7520	20.00	52.50	
		29	79	54	210	8,980	0.5992	0,6040	48.50	52,50	0		79	29	130	246	11.920	0.8015	0.7450	25.00	52.50	
		29	79	54	210	8,780	0,7985	0.8690	12.00	52.50	0		79	29	130	246	11.920	0.8015	0.7540	30.00	52.50	
		29	79	54	210	8,980	0,7985	0.8510	15,00	52.50	0		29	29	130	246	11.920	0.8015				
		29	79	54	210	8,780	0.7985	0.8410	20.00	52.50	ō		79						0.7580	35.00	52.50	
		29	79	54	210	8.780	0.7985	0.8340	25,00	52.50	ŏ			29	130	246	11,920	0.8015	0.7510	40.00	52.50	
		27	79	54	210	8,780	0.7985				-		79	29	1070	2150	2.220	0,2012	0.1570	5.00	52,50	
								0.8260	30.00	52,50	0		79	29	1070	2150	2.220	0.2012	0.1540	10.00	52.50	
		22	79	54	210	8.980	0.7985	0.8150	40.00	52,50	0		79	29	1070	2150	2,220	0.2012	0.1400	20.00	52.50	
		29	79	54	210	8,980	0.7985	0,8000	48,50	52,50	0		79	29	1070	2150	2.220	0.2012	0.1220	30,00	52.50	
		29	79	1828	5790	0.933	0.1983	0.1660	10.00	52.50	1		79	29	1070	2150	2,220	0.2012	0.1100			
	170	29	79	1828	5790	0.933	0.1983	0.1550	12.00	52.50	1	230	79	29	1070					40.00	52.50	
		29	79	1828	5790	0.933	0.1983					230				2150	2.220	0.4010	0.3340	5.00	52.50	
		29	79	1828				0.1360	15.00	52,80	1		79	29	1070	2150	2,220	0.4010	0.3320	10.00	52,50	
					5290	0.933	0.1983	0.1090	20,00	52.50	1		79	29	1070	2150	2.220	0.4010	0.3040	20.00	52,50	
		29	79	1828	5790	0,933	0.1983	0.0970	25.00	52.50	1		29	29	1070	2150	2.220	0.4010	0.2750	39.00	52,50	
		29	79	1928	5790	0.933	0.1983	0,0870	30.00	52.50	1		79	29	1070	2150	2.220	0,4010	0.2530	40,00	52,50	
		27	79	1820	5790	0.933	0.1983	0.0670	40.00	52,50	1		79	29	1070	2150						
		29	79	1828	5790	0.933	0,1783	0.0470	48.50		1						2.220	0.6036	0.5330	5.00	52.50	
		29	79	1828	5790	0.933				52.50	-		79	29	1070	2150	2.220	0.6036	0.5310	10.00	52.50	
							0.3964	0.3540	10.00	52,50	1		79	29	1070	2150	2.220	0.6036	0,5000	20.00	52.50	
		22	79	1828	5790	0.933	0.3964	0.3250	12.00	52.50	1		7 9	29	1070	2150	2.220	0.6036	0.4620	30.00	52.50	
		29	79	1828	5790	0.933	0.3964	0.2950	15.00	52,50	1		79	29	1070	2150	2.220	0.6036	0.4280	40.00	52.50	
	180	27	79	1828	5790	0.933	0.3964	0.2470	20.00	52.50	1	240	79	29	1070	2150	2,220	0.8015	0.7650	5.00	52.50	

b

		79	29	1070	2150	2.220	0.8015	0.7490	10.00	52.50	2	
		79	29	1070	2150	2.220	0.8015	0.7280	20.00	52.50	2	
		79	29	1070	2150	2,220	0.8015	0.7040	30.00	52.50	2	
		79	29	1070	2150	2.220	0.8015	0.6750	40.00			
		51	83	413	1417	4.132				52.50	2	
			83	413			0.6255	0.6817	5.00	52.50	1	
		51			1417	4.132	0.6255	0.6255	10.00	52.50	1	
		51	83	413	1417	4.132	0.6255	0.5708	15.00	52.50	1	
		51	83	413	1417	4.132	0.6255	0.5567	20.00	52.50	1	
		51	83	413	1417	4,132	0.6255	0.5268	25.00	52,50	1	
	250	51	83	413	1417	4.132	0.6255	0,4990	30.00	52.50	1	
		51	83	413	1417	4.132	0.5344	0.5954	5.00	52,50	1	
		51	83	413	1417	4.132	0.5344	0.5344	10.00	52,50	1	
		51	83	413	1417	4.132	0.5344	0.4980	15.00	52.50	1	
		51	83	413	1417	4.132	0.5344	0.4632	20.00	52.50	ī	
		51	83	413	1417	4,132	0.5344	0.4335	25.00	52,50	1	
		51	83	413	1417	4,132	0.5344	0.4063	30,00	52.50	ī	
		51	83	413	1417	4.132	0.4602	0.5222	5.00	52.50	1	
		51	83	413	1417	4,132	0.4602	0.4602	10.00	52.50	1	
		51	83	413	1417	4.132	0.4602	0,4242				
	260	51	83	413	1417	4.132	0.4602		15.00	52,50	1	
	200	51	83	413	1417	4,132		0.3906	20.00	52.50	1	
		51	83				0.4602	0.3624	25.00	52,50	1	
,				413	1417	4.132	0.4602	0.3370	30.00	52.50	1	
		51	83	413	1417	4.132	0.3130	0.3687	5.00	52,50	1	
		51	83	413	1417	4.132	0.3130	0.3130	10.00	52.50	1	
		51	83	413	1417	4.132	0.3130	0.2825	15.00	52:50	1	
1		51	83	413	1417	4.132	0.3130	0.2552	20.00	52,50	1	
ĺ		51	83	413	1417	4,132	0.3130	0.2330	23.00	52.50	1	
		51	83	413	1417	4.132	0.3130	0.2136	30.00	52.50	1	
1		51	83	413	1417	4.132	0,1664	0.2038	5,00	52.50	1	
}	270	51	83	413	1417	4.132	0.1664	0.1664	10.00	52.50	1	
I		51	83	413	1417	4.132	0.1664	0.1471	15,00	52.50	1	
1		51	83	413	1417	4.132	0.1664	0.1305	20.00	52,50	î	
•		51	83	413	1417	4.132	0.1664	0,1174	25.00	52,50	i	
		51	83	413	1417	4.132	0.1664	0.1064	30.00	52,50	i	
		51	83	413	1417	4.132	0.1058	0.1317	5.00	52,50	i	
•		51	83	413	1417	4.132	0.1058	0,1058	-			
		51	83	413	1417	4.132	0.1058		10.00	52.50	1	
		51	83	413	1417	4.132		0.0728	15.00	52.50	1	
		51	83	413	1417		0.1058	0.0817	20.00	52.50	1	
	280	51	83	413		4.132	0.1058	0.0731	25.00	52.50	1	
	200	51	83	413	1417	4.132	0.1058	0.0659	30.00	52.50	1	
			83		1417	4.132	0.0502	0.0635	5.00	52.50	1	
		51		413	1417	4,132	0.0502	0.0502	10.00	52.50	1	
		51	83	413	1417	4.132	0.0302	0.0437	15.00	52.50	1	
		51	83	413	1417	4.132	0.0502	0.0382	20,00	52.50	1	
		51	83	413	1417	4,132	0.0502	0.0340	25,00	52.50	1.	
		51	83	413	1417	4,132	0.0502	0.0306	30.00	52.50	1	
		51	83	413	1417	4.132	0.0277	0.0352	5.00	52.50	1	
		51	83	413	1417	4.132	0.0277	0.0277	10,00	52,50	1	
		51	83	413	1417	4.132	0.0277	0.0240	15.00	52,50	1	
	290	51	83	413	1417	4.132	0.0277	0.0210	20,00	52.50	ĩ	
		51	83	413	1417	4.132	0.0277	0.0186	25.00	52.50	ī	
		51	83	413	1417	4.132	0.0277	0.0167	30.00	52.50	î	
		92	6	621	57	3.720	0.9080	0.8550	10.00	52.50	2	
		92	6	621	57	3.720	0.9080	0.8680	15.00	52.50	2	
		92	6	621	57	3.720	0.9080	0.8780	20.00			
		92	6	621	57	3.720	0.9080	0.8870	25.00	52.50	2	
		92	6	621	57	3.720	0.9080	0.8980		52.50	2	
		92	6	621	57	3.720	0.7080		30.00	52.50	2	
		92	7	621	92	3.720	0.9440	0,9070 0,9090	35.00	52.50	2	
	300	92	ź	621	92	3.720	0.9440	0.9090	10.00	52,50	2	
					, <u> </u>		01/440	V+7100	15.00	52.50	2	

										_
	92	7	621	92	3.720	0.9440	0.9260	20,00	52,50	2
	92	7	621	92	3.720	0.9440	0.9330	25.00	52.50	2
	72	7	621	92	3.720	0.9440	0.9380	30.00	52,50	2
	92	7	621	92	3.720	0.9440	0.9430	33.00	52,50	2
	92	14	621	704	3.720		0.9390			2
						0.9620		10.00	52,50	
	92	14	621	704	3.720	0.9620	0.9430	15.00	52,50	2
	92	14	621	704	3.720	0.9620	0.9460	20.00	52.50	2
	92	14	621	704	3.720	0.9620	0.9480	25.00	52,50	2
	92	14	621	704	3.720	0.9620	0.9490	30,00	52.50	2
310	92	14	621	704	3.720	0,9620	0.9500	35.00	52.50	2
510	92	15	621	847	3.720	0.8840	0.8220			2
								10.00	52,50	
	92	15	621	847	3.720	0.8840	0.8310	15.00	52.50	2
	92	#15	621	847	3.720	0.8840	0.8380	20.00	52.50	2
	92	(15	621	847	3.720	0.8840	0.8430	25.00	52.50	2
	92	45	621	847	3,720	0,8840	0.8450	30.00	52.50	2
	92	15	621	847	3.720	0.8840	0.8470	35.00	52,50	2
	92	16	621	1004	3.720	0.8810	0.8140	10.00	52.50	2
	92	16	621	1004	3.720	0,8810	0.8210	15.00	52.50	2
	92	16	621	1004	3.720	0.8810	0.8270	20.00	52.50	2
320	92	16	621	1004	3,720	0.8810	0.8290	25.00	52.50	2
	92	16	621	1004	3.720	0.8810	0.8290	30.00	52.50	2
	92	16	621	1004	3.720	0.8810	0.8270	35,00	52.50	2
	92	26	621	424	3,720	0.9620	0.9440	10.00	52.50	2
	92	26	621	424	3.720	0.9620	0.9490	15.00	52,50	2
	92	26	621	424	3,720	0,9620	0.9530	20.00	52.50	
	92	26	621		3.720					2
				424		0.9620	0.9560	25.00	52.50	2
	92	26	621	424	3.720	0.9620	0.9580	30,00	52.50	2
	92	26	621	424	3.720	0.9620	0.9600	35.00	52.50	2
	20	26	59	380	8.332	0.0980	0,0973	10.00	75,00	0
330	28	26	59	380	8.332	0.0980	0.0716	15.00	75.00	0
	28	26	59	380	8.332	0.0780	0.0886	20.00	75.00	0
	28	26	59	380	8.332	0.0980	0.0858	25.00	75.00	ŏ
	28	26	59	380	8.332					
						0.0980	0.0835	30.00	75.00	0
	20	26	59	380	8.332	0.0980	0.0776	35.00	75.00	0
	28	26	59	380	8.332	0.0980	0.0746	40.00	75.00	0
	28	26	59	380	8.332	0.0980	0.0978	10.00	20,00	0
	28	26	59	380	8.332	0.0780	0.0889	15.00	20.00	0
	28	26	59	380	8.332	0.0980	0.0802	20.00	20.00	0
	20	26	59	380	8.332	0.0780	0.0735	25.00	20.00	ō
340	28	26	59	380	8.332	0.0980	0.0658	30.00	20.00	ŏ
540	28	26	59	380						
					8.332	0.0780	0.0569	35.00	20.00	0
	28	26	59	380	8.332	0.0780	0.0500	40.00	20.00	0
	13	12	386	4377	1.560	0.0910	0.0660	10.00	75.00	0
	13	12	386	4377	1.560	0.0910	0.0473	15.00	75,00	0
	13	12	386	4377	1.560	0.0710	0.0351	20.00	75.00	0
	13	12	396	4377	1,560	0.0910	0.0258	25.00	75.00	0
	13	12	386	4377	1.560	0.0910	0.0178	30,00	75,00	ò
	13	12	386	4377	1.560	0.0710	0.0152	35,00	75.00	ō
	13	12	386	4377	1.560	0.0910	0.0123	40.00	75.00	ŏ
250										
350	13	12	386	4377	1.560	0.0910	0.0602	10.00	52.50	0
	13	12	386	4377	1.560	0.0910	0.0424	15.00	52.50	0
	13	12	386	4377	1,560	0.0910	0.0302	20.00	52.50	0
	13	12	386	4377	1.560	0.0910	0.0221	25.00	52.50	0
	13	12	386	4377	1.560	0.0710	0.0168	30.00	52.50	0
	1.3	12	386	4377	1.560	0.0710	0.0395	10.00	20.00	ō
	13	12	386	4377	1.560	0,0710	0.0252	15.00	20.00	ŏ
	13	12	386	4377	1.560	0.0910	0.0169	20.00		ŏ
									20.00	
	13	12	386	4377	1.560	0.0910	0.0122	25.00	20.00	0
	13	12	386	4377	1.560	0.0910	0.0095	30.00	20.00	0
360	1.3	12	386	4377	1.560	0.0710	0.0079	35.00	20.00	0

. -

SCANNING Vol. 8, 2 (1986)

G. F. Bastin et al.: Improvement in the Gaussian $\Phi(\varrho z)$ approach for matrix correction

2

С

		13	12	386	4377	1.560	0.0910	0.0069	40.00	20.00	0			41	23	726	887	2.371	0.0800	0.0739	20.00	75,00	1	
		13	26	386	3841	1.560	0.1000	0.0868	10.00	75.00	ŏ			41	23	726	689	2.371	0.0800	0,0730	25.00	75.00	1	
		13	26	306	3941									41	23	726	889	2.371	0.0800	0,0722	30.00	75.00	1	
						1.560	0.1000	0.0692	15.00	75.00	0												1	
		13	26	306	3841	1.560	0.1000	0.0543	20.00	75.00	<u> </u>			41	23	726	887	2.371	0.0800	0.0707	35.00	75,00	1	
		13	26	386	3841	1.560	0.1000	0.0415	25.00	75.00	Ó			41	23	726	887	2.371	0.0800	0.0684	40,00	75,00	1	
		1.3	26	386	3841	1.560	0.1000	0.0337	30.00	75.00	0			41	23	726	889	2.371	0.0800	0.0757	10.00	52.50	1	
		13	26	383	3841	1.560	0.1000	0.0268	35.00	75.00	ō			41	23	726	889	2.371	0.0800	0.0761	15.00	52.50	1	
			26	386	3841						.,			41	23	726	889		0.0800				4	
		13				1.560	0.1000	0.0218	40.00	75.00	0							2.371		0.0730	20.00	52.50	T.	
		13	26	386	3841	1,+560	0.1000	0.0765	10.00	52.50	0			41	23	726	867	2.371	0.0800	0.0698	25.00	52.50	1	
	370	1.3	26	386	3841	1.560	0.1000	0,0592	15.00	52.50	0		430	41	23	726	889	2.371	0,0800	0,0657	30.00	52,50	1	
		1.3	26	386	3841	1.560	0.1000	0.0431	20.00	52.50	0			41	23	726	889	2.371	0,0800	0.0705	10.00	20.00	1	
		1.3	26	386	3841	1.560	0.1000	0.0335	25.00	52,50	Ö			41	23	726	887	2.371	0.0800	0.0693	15.00	20.00	1	
		13	26	386	3941	1.560	0,1000	0.0266	30.00	52.50	ŏ			41	23	726	889	2.371	0.0800	0.0680	20.00	20.00	1	
		13	26	386	3841	1.560	0,1000	0.0530			-			41	23	726	809	2.371					.1.	
									10.00	20.00	0								0.0800	0,0652	25,00	20.00	1	
		13	26	386	3841	1.560	0.1000	0.0354	15.00	20.00	0			41	23	726	887	2,371	0,0800	0.0614	30,00	20.00	3	
		1.3	26	386	3041	1.560	0.1000	0.0249	20.00	20.00	0			41	23	726	889	2.371	0.0800	0.0571	35.00	20.00	1	
		13	26	386	3841	1.560	0.1000	0.0185	25.00	20.00	0			41	23	726	889	2.371	0.0800	0.0530	40.00	20,00	1	
		1.3	26	386	3841	1.560	0.1000	0.0149	30.00	20.00	0			33	31	38	233	11.860	0.5180	0.4920	15.00	20.00	Ó	
		13	26	386	3841	1.560	0.1000	0.0126	35.00	20.00	0			33	31	38	233	11.860	0.5100	0.4770	20.00	20,00	ŏ	
	380	1.3	26	386	3841	1.560	0,1000	0.0114					440	33	31	38	233	11.860						
	290								40.00	20,00	0		440						0.5180	0.4650	25.00	20.00	0	
		14	26	350	2310	1.840	0.0840	0.0846	10.00	75.00	0			33	31	38	233	11.860	0.5180	0.4460	30.00	20.00	0	
5		14	26	350	2310	1.840	0.0860	0,0723	15.00	75,00	Ó			33	31	39	233	11.860	0.5180	0.4280	35.00	20,00	0	
ž		14	26	350	2310	1.840	0.0860	0,0615	20.00	75.00	0			33	49	38	117	11.860	0.3950	0.4180	15.00	20.00	0	
1		14	26	350	2310	1.840	0.0860	0.0517	25.00	75.00	0			33	49	38	117	11.860	0.3750	0,4050	20.00	20.00	Ō	
		14	26	350	2310	1.840	0.0860	0.0431	30.00	75.00	õ			33	49	38	117	11.860	0.3950	0.3940	25.00	20,00	ő	
7 .		14	26	350							-				49								- · ·	
7					2310	1.840	0.0860	0.0352	35.00	75.00	0			33		38	117	11.860	0.3950	0,3850	30.00	20.00	0	
4		14	26	350	2310	1.840	0.0840	0.0277	40.00	75.00	0			33	49	38	117	11,860	0.3950	0.3770	35.00	20.00	0	
プ		1.4	26	350	2310	1.840	0,0860	0.0829	10.00	52.50	0			49	15	463	890	3.730	0.7870	0.7180	10.00	20.00	1	
2		1.4	26	350	2310	1.840	0.0860	0.0677	15.00	52.50	0			49	15	463	890	3.730	0.7870	0,7170	15.00	20,00	1	
ີ ລ	390	1.4	26	350	2310	1.840	0.0860	0.0544	20.00	52,50	0		450	49	15	463	890	3.730	0.7870	0,7090	20.00	20.00	1	
1		14	26	350	2310	1.840	0.0860	0.0446	25.00	52.50	Ő			49	15	463	890	3.730	0,7870	0.6910	25.00	20.00	1	
5		14	26	350	2310	1.840	0.0840	0.0354	30.00		ŏ			49	15	463	870	3.730	0.7870	0.6770				
<u> </u>		14	26	350	2310					52.50	.,			49	15		890				30,00	20.00	1	
						1,840	0.0860	0.0662	10.00	20.00	0					463		3,730	0.7870	0.6740	35.00	20.00	1	
−x		14	26	350	2310	1.840	0.0890	0.0446	15.00	20.00	0			49	33	463	909	3,730	0.6050	0.5690	10.00	20.00	1	
		1.4	26	350	2310	1.840	0+0860	0.0362	20.00	20.00	0			49	33	463	909	3.730	0.6050	0.5630	15.00	20,00	1	
		14	26	350	2310	1.840	0.0860	0.0254	25,00	20.00	0			49	33	463	909	3.730	0,6050	0.5390	20.00	20.00	3	
		14	26	350	2310	1.840	0.0860	0.0211	30.00	20.00	Ö			49	33	463	909	3.730	0.6050	0.5210	25.00	20.00	1	
7		14	26	350	2310	1.840	0.0860	0.0178	35.00		ŏ			49	33	463	909	3.730	0.6050	0,4980	30.00		1	
8		14	26	350						20.00	•			49	33							20.00	1	
Š.					2310	1.840	0.0860	0.0154	40.00	20.00	0					463	909	3.730	0.6050	0.3000	35.00	20.00	1	
-	400	23	14	98	235	5.460	0.4700	0.4371	10.00	75.00	Ö		460	51	31	413	589	4.130	0.6360	0.5990	10.00	20 .0 0	1	
		23	14	98	235	5.460	0.4700	0.4356	15.00	75.00	0			51	31	413	589	4.130	0,6360	0.5980	15.00	20.00	1	
		23	14	98	235	5.460	0.4700	0.4342	20.00	75,00	0			51	31	413	589	4.130	0.6360	0.5940	20.00	20.00	1	
		23	14	98	235	5,460	0.4700	0.4327	25,00	75.00	0			51	31	413	589	4.130	0.6360	0.5800	25.00	20.00	1	
		23	14	98	235	5.460	0.4700	0.4303	30.00	75.00	ŏ			51	31	413	589	4.130	0.6360	0,5710	30.00	20,00	1	
		23	14	78	235	5.460	0.4700							51	31	413	507	4,130					1	
		23		-				0.4267	35.00	75.00	0								0.6360	0.5710	35.00	20.00	L	
			14	98	235	5.460	0.4700	0.4234	40.00	75.00	0			51	49	413	364	4.130	0.5150	0.5300	10.00	20,00	1	
		23	14	98	235	5.460	0.4700	0.4475	10.00	52,50	0			51	49	413	364	4.130	0.5150	0.5410	20.00	20.00	1	
		23	14	98	235	5.460	0.4700	0.4416	15.00	52.50	0			51	49	413	364	4.130	0.5150	0,5430	30.00	20,00	1	
		23	14	98	235	5.460	0.4700	0.4342	20.00	52.50	0			25	51	80	627	6.530	0.4740	0.4600	15.00	20.00	0	
	410	23	14	98	235	5.460	0.4700	0.4247	25.00	52.50	Ö		470	25	51	80	627	6.530	0.4740	0.4210	20.00	20.00	Ō	
		23	14	98	235	5.460	0.4700	0.4143	30.00	52,50	ŏ			25	51	80	627	6.530	0.4740	0.3840	25.00	20.00	ő	
		23	14	98	235	5.460									51									
							0.4700	0.4303	10.00	20.00	0			25		80	627	6.530	0.4740	0.3500	30.00	20,00	0	
		23	14	98	235	5.460	0,4700	0.4214	15,00	20,00	0			82	16	117	42	13.040	0,8640	0.8070	20.00	75,00	1	
		23	14	98	235	5.460	0.4700	0.4113	20,00	20.00	0			02	16	117	42	13.040	0.8660	0.8090	25.00	75.00	i	
		23	14	98	235	5.460	0,4700	0.3978	25.00	20.00	0			62	16	117	42	13.040	0.8660	0.8130	30.00	75.00	î	
		23	14	98	235	5,460	0.4700	0.3861	30.00	20.00	ŏ			82	16	117	42	13.040	0.8660	0.8180	35.00	75.00	1	
		23	14	98	235	5.460	0.4700	0.3722	35.00	20.00	ŏ			82	16	117	42	13.040	0.8660	0.8260	40,00	75.00	1	
		23	14	98	235	5.460	0.4700				-			30	16		73	7.660	0.6710				1	
		41			807			0.3582	40.00	20.00	0					49				0.6200	20.00	75.00	0	
			23	726		2,371	0.0800	0.0730	10.00	75.00	1			30	16	49	73	9.660	0.6710	0.6260	25.00	75.00	0	
	420	41	23	726	889	2.371	0.0800	0.0740	15.00	75.00	1	~	480	30	16	49	73	9.660	0.6710	0.6280	30.00	75.00	0	

SCANNING Vol. 8, 2 (1986)

G. F. Bastin et al.: Improvement in the Gaussian $\Phi(\varrho z)$ approach for matrix correction

d

65

							-												-				е	66
		5	6	3350	6350	0.100	0,7981	0.7768	4.00	40.00	0			26	6	69	9	7.111	0.9333	0.9290	25.00	40.00	0	
		5	6	3350	6350	0.188	0.7981	0.7754	6.00	40.00	Ö			26	6	69	9	7.111	0.9333	0.9304	30.00	40.00	ő	
		5	6	3350	6350	0.188	0.7981	0,7471	8.00	40,00	0			40	6	778	284	2.223	0.9145	0.8981	4.00	40.00	ĩ	
		5	6	3350	6350	0,189	0,7981	0,7309	10.00	40.00	0	Χ.		40	6	778	284	2.223	0.9145	0,9011	6.00	40.00	1	
		5	6	3350	6350	0.188	0,7981	0.7132	12.00	40,00	0			40	6	779	284	2.223	0.9145	0,9033	8.00	40,00	1	ନ
		5	6	3350	6350	0.188	0.7981	0.6853	15.00	40.00	0			40	6	778	284	2.223	0.9145	0,9055	10.00	40.00	1	•
		5	6	3350	6350	0.198	0.7981	0.6544	20,00	40.00	0			40	6	778	284	2.223	0.9145	0,9070	12,00	40.00	1	Ţ
		5	6	3350	6350	0.188	0,7981	0.6516	25.00	40.00	0			40	6	770	284	2.223	0.9145	0,7088	15.00	40.00	1	, H
	490	5 1.4	6	3350 350	6350 455	0.188 1.840	0,7981	0.6574 0.6800	30.00	40,00	0			40	6	278	284	2.223	0.9145	0.9095	20.00	40.00	1.	Ba
	490	14	6	350	455	1.840	0.7005 0.7005	0.6798	4.00	40.00	ő		550	40	6	778	284	2.223	0.9145	0.9100	25.00	40,00	1	astin
		14	6	350	455	1.840	0.7005	0.6790	8,00 8,00	40,00 40,00	ő			40 41	6	778	284	2,223	0.9145	0.9110	30.00	40,00	1	H
		1.4	6	350	455	1.840	0.7005	0.6787	10.00	40.00	õ			41	ž	726 726	239 239	2+371 2+371	0.9145	0.8750	4.00	40.00	1	
		14	6	350	455	1.840	0.7005	0.6780	12.00	40.00	ŏ			41	6	726	239	2.371	0+9145 0+9145	0.0022 0.8880	8.00	40,00 40,00	1. 1.	et
		14	6	350	455	1,840	0.7005	0.6762	15.00	40.00	ŏ			41	6	726	239	2.371	0.9145	0,8930	10.00	40.00	г 1	e۵
		14	6	350	455	1.840	0.7005	0.6730	20.00	40.00	ő			41	6	726	239	2.371	0.9145	0,8970	12.00	40.00	1	
		1.4	6	350	455	1.840	0.7005	0.6682	25.00	40.00	0			41	6	726	239	2.371	0.9145	0.9022	15.00	40.00	1	
		1.4	6	350	455	1.840	0,7005	0.6630	30.00	40.00	0			41	6	726	239	2.371	0.9145	0.9098	20.00	40.00	1	Improveme
		22	6	108	26	4.965	0.8160	0,7832	6,00	40.00	0			41	6	726	239	2.371	0.9145	0,9135	25.00	40.00	ĩ	q
	500	22	6	108	26	4.965	0.8160	0.7862	8,00	40,00	0		560	41	6	726	239	2.371	0.9145	0.9175	30,00	40.00	1	rc
		22	6	108	26	4.965	0.8160	0.7988	10.00	40.00	0			42	6	684	202	2.523	0,9442	0.9060	4.00	40.00	1	V.
1		22 22	6	108 108	26	4.965	0.8160	0,7910	12.00	40.00	0			42	6	684	202	2.523	0.9442	0.9128	6.00	40.00	1	en
}		22	6	108	26 26	4,965 4,965	0.8160 0.8160	0,7938 0,7980	15.00	40.00	0			42	6	684	202	2.523	0.9442	0.9182	8.00	40.00	1	ne
		22	6	108	26	4.965	0,8160	0.9012	20.00 25.00	40.00 40.00	0			42	6	684	202	2.532	0.9442	0.9225	10.00	40.00	1	'n
		22	6	108	26	4.965	0.8160	0.8033	30.00	40.00	õ			42 42	6 6	684	202	2.523	0.9442	0.9264	12.00	40.00	1	H
		23	6	95	20	5.464	0.8400	0,7952	6.00	40.00	ŏ			42	6	684 684	202 202	2+523 2+523	0.9442	0.9312 0.9373	15.00	40.00	1	in
		23	6	95	20	5,464	0.8400	0.8013	8.00	40.00	ŏ			42	6	684	202	2.523	0.9442	0.93/3	20.00 25.00	40,00 40,00	1 1	±.
		23	6	95	20	5.464	0.8400	0.8065	10.00	40.00	ŏ			42	Ă	684	202	2,523	0.9442	0.9458	30.00	40.00	1	the
	510	23	6	95	20	5.464	0.8400	0.8111	12.00	40.00	ō		570	73	6	1274	464	1.743	0.9400	0.8765	4.00	40.00	2	
		23	6	95	20	5.464	0.8400	0.8162	15.00	40.00	0			73	6	1274	464	1.743	0.9400	0.8815	6.00	40.00	ž	Gaussia
		23	6	95	20	5.464	0.8400	0.8220	20.00	40.00	0			73	6	1274	464	1.743	0.9400	0.8862	8.00	40,00	2	ue
		23	6	95	20	5.464	0.8400	0,8265	25.00	40,00	0			73	6	1274	464	1.743	0,9400	0.8705	10.00	40,00	2	SS
		23	6	25	20	5,464	0.8400	0.8295	30.00	40.00	0			73	6	1274	464	1.743	0.9400	0.8943	12.00	40.00	2	13
		24	6	83	15	5.989	0.9432	0.9252	8.00	40.00	0			73	6	1274	464	1.743	0.9400	0.9000	15.00	40,00	2	5
		24 24	6	83 83	15	5,989	0.9432	0,9257	10.00	40.00	0			73	6	1274	464	1.743	0.9400	0.9088	20.00	40.00	2	Ф
		24 24	6	83	15 15	5,989 5,989	0.9432 0.9432	0.9259	12.00	40.00	0			73	6	1274	464	1.743	0.9400	0.9162	25.00	40.00	2	Ř
		24	6	83	15	5.989	0.7432	0.9261 0.9265	15.00 20.00	40.00	0			23	6	1247	464	1.743	0.9400	0,9220	30.00	40.00	2	(oz)
	520		6	83	15	5.989	0.9432	0.9271	25.00	40,00 40,00	0		580	73 73	6 6	159 159	4	9.877 9.877	0,9400 0,9400	0,8820 0,8884	12.00	40.00	1	÷
		24	6	83	15	5.989	0.9432	0.9278	30.00	40,00	ŏ		300	73	6	157	4	9.877	0.9400	0.8780	15,00 20,00	40.00 40.00	1 1	a
		24	6	83	15	5,989	0.9090	0.8790	8.00	40.00	ŏ			73	6	159	4	9.877	0.9400	0.9060	25,00	40.00	1	Įq
		24	6	83	15	5.989	0.9090	0.8817	10.00	40.00	ŏ			73	6	159	4	9.877	0.9400	0.9130	30.00	40.00	1	approac
		24	6	83	15	5.989	0.9090	0.8842	12.00	40.00	Ō			73	6	1274	464	1.743	0.9700	0.9342	4.00	40.00	ź	Da
		24	6	83	15	5.989	0.9090	0.8875	15.00	40.00	0			73	6	1274	464	1,743	0.9700	0.9390	6.00	40.00	2	Ċ
		24	6	83	15	5,989	0,9090	0,8918	20.00	40.00	0			73	6	1274	464	1.743	0.9700	0.9428	8.00	40.00	2	Ц
		24	6	83	15	5.989	0.9090	0.8950	25.00	40.00	0			73	6	1274	464	1.743	0.9700	0,9462	10.00	40.00	2	for
		24 24	6	83 83	15	5.989	0,9090	0.8972	30.00	40.00	0			73	6	1274	464	1.743	0.9700	0.9490	12,00	40,00	2	
	530		6	83	15 15	5,989 5,989	0.8666	0,8310	8.00	40.00	0			73	6	1274	464	1.743	0.9700	0.9540	15.00	40.00	2	matrix
	550	24	6	83	15	5.787	0.8666 0.8666	0.8322 0.8358	10.00	40.00	0		590	73	6	1274	464	1.743	0.9700	0.9602	20.00	40.00	2	at
		24	6	83	15	5.989	0.8666	0.8385	12.00 15.00	40,00 40,00	0			73 73	6	1274 1274	464	1.743	0.9700	0.9660	25.00	40.00	2	Ξ.
		24	6	83	15	5,787	0.8666	0.8422	20.00	40,00	ŏ			73	6 6	159	464	9.877	0.9700 0.9700	0.9702 0.9348	30.00 12.00	40.00 40.00	2	
		24	6	83	15	5.989	0.8666	0.8455	25.00	40.00	ŏ			73	6	159	4	9.877	0.9700	0.7346	15.00	40.00	1	correction
		24	6	83	15	5.989	0.8666	0.8478	30.00	40,00	ŏ			73	6	157	4	9.877	0,9700	0.9453	20.00	40.00	1	Ĕ
		26	6	69	9	7.111	0.9333	0.9172	8.00	40.00	ŏ			73	6	159	4	9.877	0.9700	0.9503	25.00	40.00	1	ſe
		26	6	69	9	7.111	0,9333	0.9194	10.00	40.00	0			73	6	159	4	9.877	0.9700	0.9543	30.00	40.00	ì	5
		26	6	69	2	7.111	0.9333	0.9215	12.00	40.00	0			74	6	1164	420	1.814	0.9387	0.8560	4.00	40,00	2	io
	E 40	26	6	69	9		0,9333	0.9239	15.00	40,00	0			74	6	1164	420	1.814	0,9387	0.9712	6.00	40.00	2	ň
	540	26	6	69	9	/.111	0.9333	0.9270	20.00	40.00	0	1	600	74	6	1164	420	1,814	0,9387	0.8823	8.00	40.00	2	

- ----

66

е

	74	6	1164	420	1.814	0,9387	0.8910	10.00	40,00	2
	74	6	1164	420	1.814	0,9387	0.8987	12.00	40.00	2
	74	6	1164	420	1.014	0.9387	0.9081	15.00	40.00	ź
	74	6	1164	420	1.814	0,9387	0.9212	20.00		
	74	6	1164	420	1.814				40.00	2
	74					0.9387	0.9328	25.00	40.00	2
		6	1164	420	1.814	0.9307	0.9428	30.00	40,00	2
	24	6	151	4	10,200	0,9397	0.8558	12.00	40.00	3
	24	6	151	4	10,200	0.9387	0.8782	15.00	40,00	1
	74	6	151	4	10,200	0.9382	0.8975	20.00	40.00	1
610	74	6	151	4	10,200	0.9387	0.9093	25.00	40.00	1
	74	6	151	4	10.200	0.9387	0.9178	30.00	40,00	1
	74	6	1164	420	1.814	0.9700	0.8865	4.00	40.00	2
	74	6	1164	420	1.614	0.9700	0,9060	6.00	40.00	2
	74	6	1154	420	1.814	0.9700	0.9178	8,00	40.00	2
	74	6	1164	420	1.814	0.9700	0.9272	10,00	40,00	2
	24	6	1164	420	1.814	0.9700	0.9350	12.00	40.00	2
	74	6	1164	420	1,814	0.9700	0.9443	15.00	40,00	2
	74	6	1164	420	1.814	0.9700	0,9568	20.00	40.00	2
	74	6	1164	420	1.814	0,9700				
6.00	74	6					0,9668	25.00	40.00	2
620			1164	420	1,814	0,9700	0.9756	30.00	40,00	2
	74	6	151	4	10.200	0,9700	0.9153	12.00	40.00	-1
	74	- 6	151	4	10,200	0.9700	0.9290	15.00	40.00	1.
	74	6	151	4	10.200	0.9700	0,9432	20.00	40,00	1
	74	6	151	4	10,200	0.9700	0.9522	25.00	40.00	1
	74	6	151	4	10.200	0.9700	0.9580	30.00	40,00	1
	13	22	386	2288	1.560	0.3980	0.3853	7.00	40.00	0
	1.3	22	386	2286	1.560	0.3780	0.3543	10.50	40.00	Ó
	13	22	386	2288	1,560	0.3780	0.3008	15/70	40.00	ō
	13	22	386	2288	1.560	0.3980	0.2585	20.80	40.00	ŏ
630	13	22	386	2288	1.560	0.3980	0.2162	26.00	40.00	ŏ
	13	22	386	2288	1.560	0.3980	0.1870	31.30	40,00	ŏ
	13	22	386	2288	1.560	0.3980	0.1579	36.40	40,00	ŏ
	1.3	22	386	2288	1.560	0.3980	0.1429	40,00	40.00	ŏ
	13	28	384	4600	1,560	0.3070	0.2957	5.30		
	13	28	386	4600	1.560	0.3070			40,00	0
	13	28					0.2184	10,50	40.00	0
			306	4600	1.560	0.3090	0.1576	15.90	40.00	0
	13	28	386	4600	1.560	0.3090	0.1141	21.20	40.00	0
	:13	28	384	4600	1.560	0,3090	0.0878	26+60	40,00	0
	1.3	28	383	4600	1.560	0.3090	0+0683	31,90	40.00	0
640	1.3	28	386	4600	1,560	0,3090	0.0570	37.20	40.00	0
	1.3	28	386	4600	1,560	0.1250	0,1246	5.30	40.00	0
•	1.3	28	386	4600	1,560	0.1250	0.0848	10,50	40.00	0
	13	28	386	4600	1,560	0.1250	0.0585	15.90	40.00	0
	13	28	386	4600	1.560	0.1250	0.0405	21.20	40,00	0
	13	28	386	4600	1.560	0.1250	0.0307	26.60	40.00	0
	13	28	386	4600	1.560	0,1250	0.0233	31.90	40.00	Ö
	13	28	386	4600	1.560	0.1250	0.0195	37.20	40.00	ŏ
	13	28	386	4600	1.560	0.0490	0.0473	5.30	40,00	ŏ
	1.3	28	388	4600	1,560	0.0490	0.0315	10.50	40.00	ŏ
650	13	28	386	4600	1.560	0.0490	0.0210	15.90	40.00	ŏ
	13	28	386	4600	1,560	0.0490	0.0143	21.20	40.00	ŏ
	13	28	386	4600	1,560	0.0490	0.0078			
	13	28	386					26.60	40.00	0
				4600	1,560	0,0490	0.0075	31,90	40.00	0
	13	28	306	4600	1.560	0.0490	0.0068	37.20	40.00	0
	29	28	1020	11700	0.933	0.5650	0.5135	2.50	40,00	1
	29	28	1828	11700	0,933	0.5650	0.4487	5.00	40.00	1
	29	28	1828	11700	0.933	0.5650	0.3876	7.60	40,00	1
	29	28	1828	11700	0.933	0.5650	0.3303	10.20	40.00	1
	29	28	1828	11700	0,933	0.5650	0.2823	12.60	40.00	1
660	27	28	1828	11700	0.933	0.5650	0.2419	15.30	40.00	1

SCANNING Vol. 8, 2 (1986)

670	22279999999999999999999999999999999999	28 28 27 77 77 77 77 77 77 77 77 77 77 77 77	1828 1828 1828 1828 1828 1828 1828 1828	11700 11700 11700 11700 5790 5790 5790 5790 5790 5790 5790 5	0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933 0,933	0.5650 0.5650 0.5650 0.5650 0.7000 0.7000 0.7000 0.7000 0.7000 0.7000 0.7000 0.7000 0.4920 0.4920 0.4920	0.1930 0.1649 0.1497 0.1395 0.1310 0.7143 0.6259 0.5489 0.4981 0.4662 0.4981 0.4229 0.4173 0.5019 0.5019 0.3383 0.2932 0.2632	$\begin{array}{c} 20.50\\ 25.60\\ 30.80\\ 35.50\\ 40.00\\ 5.20\\ 10.40\\ 15.70\\ 20.80\\ 26.10\\ 31.30\\ 34.50\\ 37.50\\ 5.20\\ 10.40\\ 15.70\\ 20.80\\ 26.10\\ \end{array}$	$\begin{array}{c} 40.00\\ 40$		
680	29 29 29 29	79 79 79 79	1828 1828 1828 1828	5790 5790 5790 5790	0,933 0,933 0,933 0,933	0,4920 0,4920 0,4920 0,4920	0.2632 0.2444 0.2368 0.2331	26.10 31.30 36.50 39.50	40.00 40.00 40.00 40.00	1 1 1 1	

f