Preface to the Second Edition

Truth is truth
to the end of reckoning

Shakespeare, Measure for Measure

Physical units, though arbitrary by nature, quantify the structure of science and technology. Therefore, in a consistent system of units, measurands need to represent *true values*—"true" with respect to the system of units being considered complete in itself.

However, metrology suffers from a basic dilemma. For technical reasons, measuring processes are accompanied by measurement errors. This is why measured results are more or less blurred. Nevertheless, the endeavours of metrology should be traceable, i.e measurement results should localize the true values of the measurands via intervals of the kind: estimator $\pm$ uncertainty. Hence, metrology needs robust evaluation procedures—robust in the sense that the procedures spawn reliably rated uncertainty intervals.

Clearly, measuring errors cannot be treated from within themselves, say, detached from the basic operating principles of measuring devices. In practice, experimenters are faced with two hurdles. The first concerns the treatment of what C.F. Gauss termed "regular or constant errors", currently referred to as *unknown systematic errors*. The second concerns the handling of random errors.

The question of how to treat unknown systematic perturbations is unresolved. In this book, I argue that the one of the keys to a satisfactory treatment of measurement errors lies in the treatment of unknown systematic perturbations via worst-case methods.

Surprisingly enough, the influence of random errors on measurement uncertainties is equally unexplored. Indeed, when attempting to establish appropriate conditions of measurement, the scope of confidence intervals as introduced by W. Gosset ("Student") appears extendable to any number of variables, an observation that follows from a reinvestigation of the role of empirical moments of second order.

In this book, the treatment of unknown systematic errors and of random errors lead to an essentially new approach to the assignment of measurement uncertainties, the *Generalized Gaussian Error Calculus*. The central topic is the compliance of the formalism with the requirements of traceability.

A point of particular concern arising from a conceivably unified error calculus involves the plethora of practice-related ad hoc approaches, e.g. [48, 51], which can now, advantageously, be cast into a comprehensible formalism. Beyond everyday applications, say, legal or scientific purposes, shifts of the numerical values of the fundamental constants of physics may be anticipated. As the effects of physics are bound by fundamental constants, numerical shifts, if substantiated, might lead to new research verifying basic concepts.

The second edition of *Measurement Uncertainties in Science and Technology* [38] orders and restructures the text of the first edition from scratch. Greater emphasis is placed on the methodology: using a range of examples, I show how to design uncertainty intervals localizing the true values of the measurands (i.e."true" in view of their relationship to the adopted system of physical units). The examples demonstrate the efficiency and reliability of the procedure. As ever, suggestions and comments are very welcome.

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