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Origin and Evolution of Conceptual Differences between Two Measurement Theories

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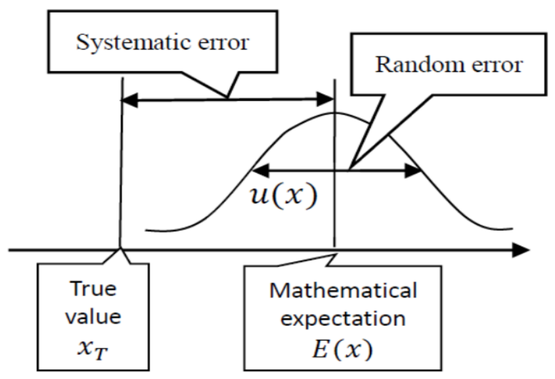
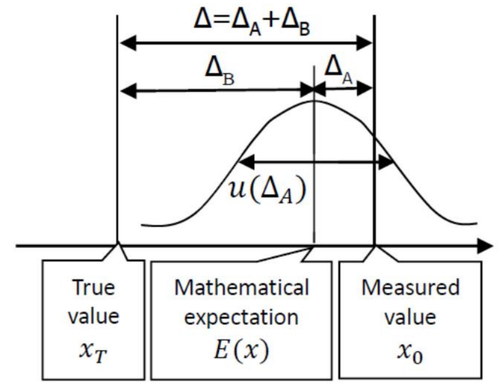
Different understanding of mathematical concepts in two theories

	Traditional measurement theory	**New concept theory**
Constant	True value and systematic error	Measured value
Random variable	Random error and measured value	Error and true value

Other major conceptual differences

	Traditional measurement theory	**New concept theory**
Conceptual sketch	 **Fig 1.** Conceptual sketch of traditional theory	 **Fig 2.** Conceptual sketch of new concept theory
Variance	The dispersion of measured value or random error	The dispersion of all possible values of an error----the evaluation of the probability interval of the error
Error epistemology	Errors are classified into systematic errors and random errors.	Both$\Delta_A$and $\Delta_B$are deviations and have their variances, and errors cannot be classified according to systematic and random way.

Conceptual troubles in traditional measurement theory

1. The expression $u(x)$ violates the mathematical concept of $\boldsymbol{u^2(C)=0}$, because measured value x is a numerical value. For example, $\begin{matrix}\boldsymbol{x=8844.43}\\ \boldsymbol{u(x)=\pm 0.21}\end{matrix} \Longrightarrow \boldsymbol{u(8844.43)=\pm 0.21}$.

2. After the measurement is completed, the mathematical expectations of the measured value, systematic error and true value cannot be submitted.

3. Both accuracy and trueness are qualitative concepts, and the total error cannot be evaluated quantitatively.

4. The conceptual relationship between precision and uncertainty cannot be explained.

5. There are logical contradictions in error classification theory, and so on.

Conceptual interpretations in new concept theory

	Measured value x_0	**Error Δ**	**True value x_T**
Mathematical expectation	x_0	0	x_0
Variance	0	$u^2(\Delta)$	$u^2(\Delta)$