Physics

Carnegie Mellon University – University of Pittsburgh
Physics Departments

Joint Physics Colloquia

Tues. March 27, 2012
4:30 - 6:00 pm
Thaw Hall, 102 PITT

RE-SCHEDULED
NEW DATE & TIME

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Personal Views of Progress in the Treatment of Measurement Uncertainties: A Revisit with Bernoulli's Ghost

ABSTRACT

About 30 years ago, I gave a seminar at Los Alamos that I had entitled: *"Bernoulli's Ghost and the Treatment of Measurement Uncertainties."* I was referring to the dilemmas associated with ascribing uncertainties in physical measurements, the problems of which were largely first annunciated by Daniel Bernoulli (1700-1782) nearly 300 years ago. Despite all of the remarkable and phenomenal discoveries in science, as well as the development of modern mathematics and statistics, since that time, the central issues and weaknesses identified by Bernoulli had never been addressed. One must appreciate that even as late as the early 1980s, the way in which uncertainties were assigned and reported in various science and engineering disciplines and between countries was pretty much chaotic and in a state of neglect. There was scant consistency and almost no logical basis or foundation for the large variety of methods that that were then in use. About the only agreement that existed was the universal belief that all measurement results needed to have an uncertainty assessment, for practical purposes – if not to appreciate the inherent value of any measurement result. How this came to be can be understood in retrospect. The physical sciences had advanced rapidly, and with the evident success achieved in understanding nature, the underlying foundations of measurement was given short shrift and has been largely ignored. Practical chemists and technologists, such as for clinical measurements, did one thing; research physicists another; and the engineers working in manufacturing ignored the concept of uncertainty entirely and pretty adopted the idea of tolerance limits. Even within disciplines there was seldom agreement or consistency. Industrial quality standards, such as those used by ASTM or ISO, varied from document to document. While research journals largely accepted whatever an author submitted. Even at the most fundamental level, of comparing the uncertainties associated with SI base unit measurements by the national metrology laboratories (such as by NIST, my laboratory, and its sister laboratories in other developed countries) there was no common reference basis for either the way an uncertainty was assessed or reported. I and others wrote extensively on this issue in this period of the late 1970s to early 1980s. In one of my early papers I described the current state as being akin to how the magistrates of the Late Roman Empire viewed the diversity of religious practices: As all equally true; all equally false; or all equally useful. With variations, the methods that were largely in use were two-fold. I had, for practical conversational purposes in being able to discuss their differences, somewhat whimsically termed them a "classical" approach that made a rigorous distinction between types of uncertainties (such as "random " and systematic" and a "romantic" approach that tried all uncertainties alike, but instead distinguished between the method used to assess them. A first practical step, at least from my personal perspective, was the establishment of a task force of US federal science agencies (EPA, NRC, DOE, DOC, NIH, etc) and industries, which was formed to develop, adopt, and disseminate uniform uncertainty assessment and reporting practices. I chaired this group, and its work is still largely in use and embodied in federal regulatory guides and good practice advisories. A few years after that I was the US representative to a BIPM Working Group that was charged with first trying to understand what the current practices among nations were, and secondly to hopefully develop guidance for the treatment and reporting of measurement uncertainties that could be adopted and used by the various international science organizations. To make a very long and convoluted story short, this working group led to the establishment of an international commission that operated under the aegis of an ISO Technical Advisory Group on Metrology with representatives from many other international science organizations and national metrology laboratories. It was hoped that any guidance developed would be based on a sound logical foundation. The "classical" vs "romantic" approach arguments that resulted quickly became vociferous. A satisfactory consensus took in excess of a decade to produce the guidance that became famously known as the "GUM" document and which is now widely used across many disciplines and throughout many nations. I was the chairman during the first, shorter-lived incarnation of the commission, and yes, the originator of the wholly unsatisfactory terminology for type-A and type-B assessments. They were never intended to be permanent labels, but the world now seems to be stuck with them. The GUM guidance has been wholly adopted by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, and its respective national entities, amongst other bodies. In the past few years, the guidance has expanded to include the development of methodologies for handling special cases, like uncertainties for multiple output values with covariance matrices, for using Monte Carlo methods, and statistical Bayesian approaches. Although there are still serious-minded dissenters who believe that the adopted approaches are fundamentally flawed and have no logical basis, the international science community has successfully achieved a consensus in adopting uniform and consistent assessment and reporting practices. Unfortunately, Bernoulli's Ghost still visits me and reminds me that all of the original dilemmas remain unresolved.

Glossary: International Association Of Testing and Materials (ASTM); International Standards Organization (ISO); US Environmental Protection Agency (EPA); US Nuclear Regulatory Commission (NRC); US Dept of Energy (DOE), US Dept of Commerce (DOC); US National Institute of Health (NIH); International Bureau of Weights and Measures (BIPM); Guide to the Expression of Uncertainty in Measurement (GUM); International Electrotechnical Commission (IEC); International Federation of Clinical Chemistry; International Union of Pure and Applied Chemistry (IUPAC); International union of Pure and Applied Physics (IUPAP); International Organization of Legal Metrology (OIML).

ABOUT THE SPEAKER

We are especially pleased to have Dr. Collé as our guest speaker. It is likely that he is more knowledgeable about topics involving the historical roots and current state of physical measurement uncertainties than anyone else in the international measurement community. Dr. Collé has been associated with the National Institute of Standards and Technology since 1975, and is widely recognized as one of the world's leading researchers in radionuclidic metrology and the development of radioactivity standards that are used in many scientific disciplines and applications. Although most of his work has principally dealt with radiochemistry and nuclear physics, he has been extensively involved in more generalized areas of metrology, including measurement quality assurance, the foundations of measurement theory, and uncertainty analyses. Dr. Collé received a B.S. in Chemistry in 1969 from the Georgia Institute of Technology, and completed a Ph.D. in Nuclear Chemistry from Rensselaer Polytechnic Institute in 1972. .