Solution to Homework 5

Question. List two cases when we do not know the probability distribution of measurement errors, and explain why.

Answer. By definition, the measurement error Δx is the difference $\Delta x = \widetilde{x} - x$ between the measurement result $\widetilde{x}$ and the actual value x of the quantity that we are measuring. Of course, we do not know the exact actual value, but we can get a good estimate for the actual value if we measure the same quantity with a much more accurate measuring instrument; such an instrument is called *standard.* So, a usual way to determine the probability distribution of measurement errors – called *calibration* – is to measure different quantities with both our current measuring instrument and the standard measuring instrument. Every time, we compute the difference between the two measurement results – which is very close to the measurement error. Based on these differences, we can find the probability distribution.

There are two important cases when this is not one:

- The first case is when we have a state-of-the-art measuring instrument, the best we can have. In this case, no measuring instrument is more accurate – so we cannot use the usual calibration procedure.
- The second case is measurement in industrial practice. In this case, in principle, we can calibrate every measuring instrument, but calibration is very expensive, since it involves the use of an expensive very accurate measuring instrument. So, to save money, companies only calibrate their sensors when it is absolutely necessary – mostly in safety critical applications such as aerospace industry and nuclear engineering.