Zero filling

Fourier transformation of the free induction decay is normally carried out digitally, so that it is necessary to sample the free induction signal at discrete, evenly spaced intervals between t = 0 and the maximum value t = T, the acquisition time. The fast Fourier transform program requires that the size of the data table to be transformed be an integral power of 2, say N = 2 n. Now, in practical cases the free induction signal often decays to a low level before all N samples have been acquired, and to avoid significant contributions from noise in the tail of this signal, a weighting function is commonly used which reduces both signal and noise to a negligible level at the end of the free induction decay. It is therefore natural to complete the data table to the next power of 2 by adding zeros.

In some other experiments, data acquisition may have to be curtailed before the free precession signal has properly decayed. This is particularly unfortunate in cases where there are two or more lines in the spectrum that are not quite resolved, because we realize that the resolving power has been unnecessarily impaired, just as in optical spectroscopy when the slit width is too large. It turns out that doubling the data table by adding an equal number of ordinates of zero intensity does in fact improve the resolution in this situation, allowing the peaks in question to be recognized as separate entities. But how can adding zeros possibly improve the quality of the information in the final spectrum? Surely, by comparison with a free induction decay followed for 2T seconds, a transient signal zero filled from T to 2T must contain false information? The key to this apparent parabox is that under normal conditions significant information is actually discarded and zero filling allows it to be retrieved.