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THE DYNODE FEEDBACK STORY

What's going on at detector/electronics level when measuring a CD spectrum?
On current CD spectropolarimeters the photomultiplier tube detector outputs two signals:
A -a DC component proportional to *energy* of light source, efficiency of the monochromator, efficiency of the detector *and* transmittance of the sample.
B - an AC component, at same frequency of the photoelastic modulator oscillation, with intensity in function of the CD effect and phase depending from its polarity
Intensity corrected CD measurements are obtained performing the ratio between the AC and the DC component.
Signal A has a chromatic behaviour since source, monochromator, detector (and of course sample!) have not a flat spectral response, but there is an easy way to get A constant: the dynode feedback.
Dynode feedback increases (or decreases) the high voltage (i.e. the gain) of the photomultiplier tube to keep DC output constant.
In this mode no ratio should be calculated and electronics measure only the AC signal through a lock-in amplifier.

This is the way your instrument usually operates.

Dynode feedback is used in other analytical instruments. For example in double beam UV-VIS spectrophotometers the *reference* path may be used to dynode feedback the high voltage applied on PM tube, in order to keep reference signal constant. Several low cost double beam spectrophotometers with PM tube operated in this way: just measuring only the *sample* signal, since reference was kept constant.
Also many spectrofluorometers use same approach with a reference PM tube sampling part of the excitation beam and compensating in this way lamp stability and (partially) excitation spectra intensity.

In our CD spectropolarimeters where are the limits of this approach? We can foresee the following three types:

1. dark current from the PM tube. Each PM tube has a dark current, dark current is strictly related to operating temperature and applied high voltage. But CD is a technique in which *a lot of light* is used. Typically dynode feedback is such as to get DC current of 50μA while dark current is in the 10nA range at maximum high voltage. Only NIR sensitive PM tubes (as the typically used R316 of S1 response) may be critical in this respect.
2. random noise level saturating the lock-in amplifier: this is the main reason. We all do quickly understand that operation above 600-700V is usually of little meaning when detecting normal intensity CD signals. Obviously this aspect is related also to the *quality* of the lock-in amplifier used.
3. response speed of the feed-back system.

Since point 1 is usually marginal, while little can be done for point 2, it would pay to see where point 3 may be relevant. We see two typical cases:

-fast kinetic (for example stopped-flow). If transmittance of the sample is changing significantly (and this also during the fast mixing phase), results may be distorted since the high voltage will not track properly the change in transmittance or will oscillate around the proper point
-very fast scanning experiments (for example when monitoring on line spectra from HPLC eluents) or even fast scanning experiments above 700 nm, where xenon lamp shows sharp emission peaks.
In both these cases it's mandatory to operate the unit at constant high voltage mode and collect (if available in your instrument) AC/DC or AC and DC simultaneously, to get later on ratio by data processing.

Note:
today several people are using Si diode detectors for NIR or also for the VIS range, particularly with supercon magnets. With these detectors no dynode feedback is obviously possible so the AC/DC or separate AC and DC collection is a must.

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