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THE PHOTOELASTIC MODULATOR

Old people like me will easily remember the Pockel cell times. Pockel cells had (at my Cary times) a typical feature ….. they were blowing up the day after warranty expired!
Apart from jokes, photoelastic modulators (PEM) have been the (probably only!) key improvement in CD technique in the last 30 years.
The PEM is the optical element which converts the linearly polarized output of your monochromator into a circular polarized one. It consists in a piezoelectric transducer which on a transparent bar shaped quartz plate is glued. The quartz bar oscillates along its dimension at a frequency determined by the length of the element (50 kHz in Jasco case). The transducer is tuned at the same frequency and driven by electronics controlling the amplitude of the vibration. The quartz plate exhibits birefringence which will cause +/-45° retardation at desired wavelength for a given oscillation amplitude. The all system is not achromatic so amplitude necessary to give proper 45° delay will be function of wavelength. So the driver is mechanically or (more recently) electronically coupled to the scanning system. The same PEM can provide 90° delay increasing the voltage applied, so same element can be used for Linear Dichroism measurement when oscillation output is increased and lock-in detector frequency is doubled. Proper ¼ wave operation is therefore obtained at different wavelengths programming with care the oscillation amplitude, while frequency is fixed. This makes the system easy to set-up and reasonably lasting forever.

Practical field problems which can be met:
-driver itself is not 100% matched with the transducer: result is overheating of the driver, sometime with failures of final power transistors
-the crystal itself is usually thermostatted, to assure better stability ….., failure in thermostatting system may not be easily noticed by the user
-modulator program (changing amplitude versus wavelength) may get out from optimal range, giving not exactly ¼ wave operation at all wavelengths. Field retuning is possible, but suitable samples with CD bands far apart are necessary
-transducer and oscillating quartz plate must be mechanically free to move, on the other hand the transducer must be kept in proper position. This is achieved through flexible supports. These may age with time and refreshment is often necessary in well used instruments

It's reported that failure rate in PEM manufacturing process is quite high, however in the field breakdown of modulator is fortunately a very rare (but still unpleasant) experience, this may be caused by a major fault in the driver system inducing abnormally high intensity oscillations.

So while field maintenance is virtually none, we would recommend your system to be inspected from time to time by a competent engineer:
-to verify proper ¼ wave function at different wavelengths
-to control status of the mechanical supports
-to verify proper thermostatting
-to check proper tuning (frequency and phase) of the associated lock-in amplifier
These operations should be carried on more frequently on instruments used routinely for LD (or ORD) operation.

Artefacts:
Even when perfectly tuned, a PEM will generate ¼ λ positive and negative delay only at the top of the oscillation, with linear and elliptical polarization in between. The lock-in used in the spectropolarimeters are typically of good quality, but it's virtually impossible to cancel out the double frequency signal generated by LD active sample. Ample literature is available on possible artefacts coming mainly from LD when dealing with oriented samples (by nature or by the sampling system adopted); apparent CD spectra are easily obtained on non-optical active samples when LD and absorption is present at the operating wavelengths. So dealing with oriented samples is very difficult and much care is recommended.

Do you want to know more about PEMs?: visit the Web of the only commercial manufacturer www.hindspem.com

E.C.S. European Chirality Services srl via Verdi 6A 23870 Cernusco Lombardone (Lc) Italy
tel/fax (0039)-039-9284368 mob 0349-6907288 e-mail ecssrl@libero.it