THREE INTERESTING PROPERTIES OF BIREFRINGENT FILTERS

Jean-Louis LEROY
Observatoires du Pic du Midi et de Toulouse
65200 Bagnères-de-Bigorre - France.

It is the purpose of this note to describe three interesting properties of birefringent filters which do not seem to have been quoted previously although they could be used with some benefit for solar observations.

1 - Solc elements in Lyot filters.

It is well known (Evans, 1958) that the Solc filter has one main advantage (high transmission) and some drawbacks (large number of plates; strong secondary maxima) with respect to the Lyot-Öhman filter. Further work (Solc, 1965) has shown that one could build apodized Solc filters which improves the value of this device; I have recently considered the design of Solc filters whose passband would be identical to that of Lyot filter : the main interest of such an apparatus would be obviously to improve the transmission of Lyot filters already in use without modifying their spectral characteristics.

It is easily shown that the equivalent of a N elements Lyot filter must be a n plates Solc filter with $n = 2^N - 1$; it is also possible to derive the set of plate orientationswhich makes the two filters equivalent. A most interesting combination is the 3 plates Solc filter equivalent to a 2 elements Lyot filter, that I call the SL 3 filter. This device reminds of course the Evans compound elements (1949) but it has the important advantage to avoid $\lambda/2$ and $\lambda/4$ plates which means that it is perfectly achromatic. Therefore a complete Lyot filter could be replaced by SL 3 elements with only half as many polarizers. Field properties of the SL 3 have also been investigated and appear to have about the same limitations as classical Lyot elements.

A detailed study of SL filters is given in a recent paper (Leroy, 1980).

2 - Birefringent filters with multiple useful pass-band.

Zirin (1966) has shown first that modern interference filters allowed to reduce drastically the number of plates in birefringent filters. As a matter of

fact birefringent elements must be kept only for the high resolution filter section because they have a wider angular field and a much more stable pass-band than multilayer devices.

With a rather large thickness for the thinnest plate of a Lyot filter it is possible to search for interesting combinations which would allow to isolate several lines of astrophysical interest at the same temperature (a problem which had been considered very early by Lyot (1944). Using SL elements which are achromatic allows to consider widely spaced spectral lines.

As an example I have shown that with a basic thickness of 8605 microns of quartz one can build a filter which selects at the same temperature four interesting solar lines : Hα; D3 (He I); b 2 (Mg I); Hβ. The bandwidth is about 2.5 Å wide, making this filter (now in progress at the Nice Observatory) a useful tool for studying solar prominences. More detailed data are reported in the previously quoted paper (Leroy, 1980) where a detailed bibliography on birefringent filters has also been gathered.

3 - Fourier transform spectrography with birefringent plates.

Mertz (1958) has shown how a birefringent wedge could be used as a polarizing interferometer for Fourier transform spectrometry. As it is fruitful to build the interferogram by a step-by-step scanning (Connes, 1966) one can also use a set of birefringent plates : figure 1 shows that the plates of a Lyot filter can be oriented in a simple way to provide a regular increase of the path difference which gives a convenient wide-field interferometer. Possible applications are likely in conjunction with the development of modern two dimensional detectors and preliminary estimates show that the birefringent device of figure 1 would have roughly the same performances than a wide field Michelson interferometer. Further, even with a noise-free detector, spectral analysis performed by Fourier transform method with the apparatus of figure 1 would be more efficient than spectral scanning with a tunable Lyot filter using the same plates because the transmission of birefringent plates alone is much higher than that of a complete filter including polaroïds.

Eventually, a very promizing application of figure 1 scheme would be spectropolarimetry : if the plates with variable orientation are set after the analyzer of a photoelectric polarimeter, one can perform a spectral analysis in polarized light without any loss of light !

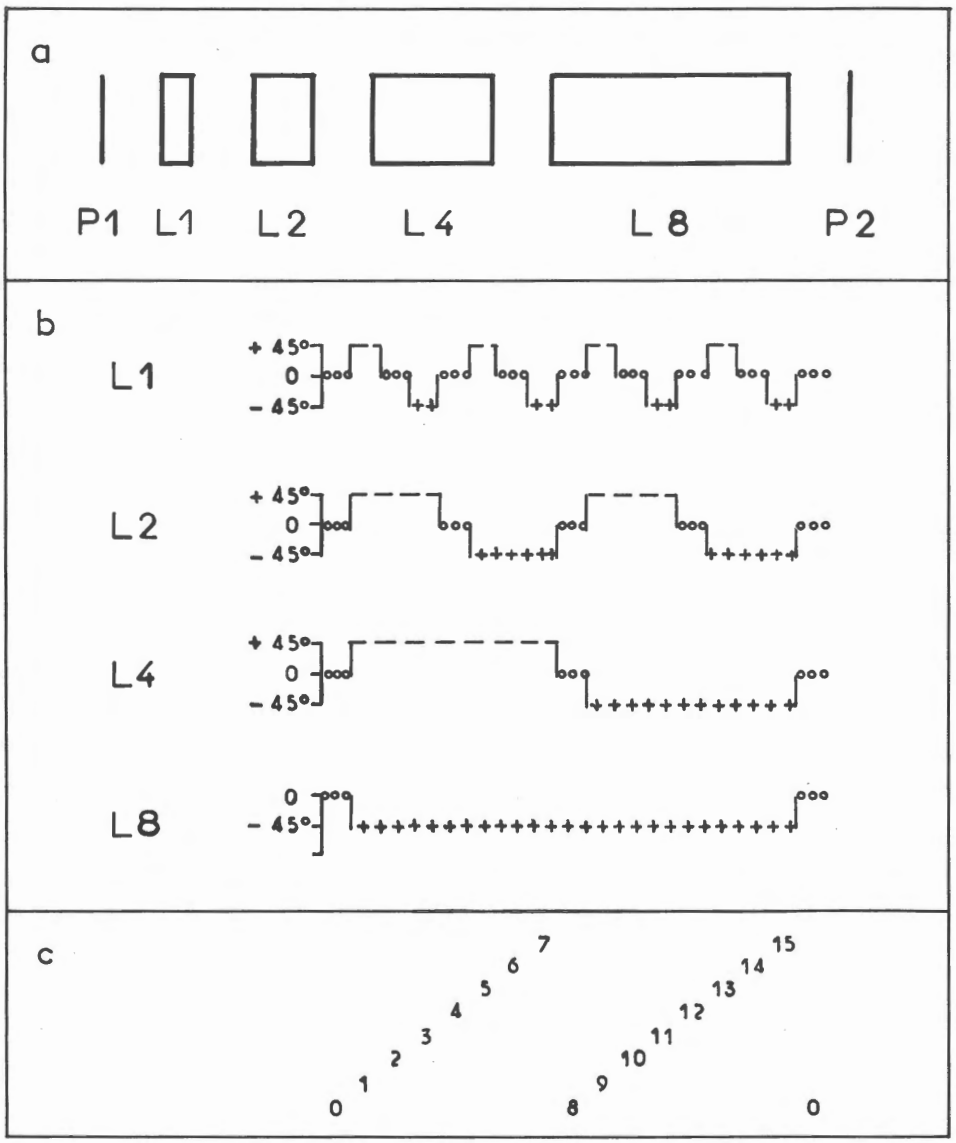

Figure 1

a/ Overall view of the birefringent device

b/ Time variation of plate orientations

c/ Resultant time variation of the path difference, in unit of plate L 1.

References

Connes, J., Connes, P., 1966, J.O.S.A., 56, 896

Evans, J.W., 1949, J.O.S.A., 39, 229

Evans, J.W., 1958, J.O.S.A., 48, 142

Leroy, J.L., 1980, Journal of Optics, 11, 293

Lyot, B., 1944, Ann. Astrophys., 7, 31

Mertz, L., 1958, J. Physique, 19, 233

Solc, I., 1965, J.O.S.A., 55, 621

Zirin, H., 1966, Applied Optics, 5, 474.