Observational Astrophysics 2 (2008): Exercises to Lectures 3 and 4 (Due on 25 September 2008 at 09:15)

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1 Rotating Retarder Polarimeter

A rotating retarder (or waveplate) polarimeter consists of a rotating retarder with retardance δ and position angle $\theta(t)$, a fixed linear polarizer, and a detector.

1.1 Modulation Signal

Show that the intensity I' measured by the detector as a function of time for an incoming Stokes vector $(I, Q, U, V)^T$ is given by

$$I' = \frac{1}{2}\left(I + \frac{Q}{2}\left((1+\cos\delta) + (1-\cos\delta)\cos 4\theta\right) + \frac{U}{2}(1-\cos\delta)\sin 4\theta - V\sin\delta\sin 2\theta\right)$$

1.2 Uniform Modulation Amplitude

Show that the modulation amplitudes in Q, U, and V are identical for δ=127°.

1.3 Measurement Intervals

Assume that the detector measures the intensity signal in n equally long time intervals for every full rotation of the retarder. How large does n need to be to detect all components of the Stokes vector.

2 Mueller Matrix

The most general Jones matrix describing the interaction of monochromatic light with matter has eight independent parameters (four complex numbers). How many independent parameters does a Mueller matrix have that describes the same interaction of a polarized beam with matter?

3 Rotating Mirror Problem

The Mueller matrix for an ideal mirror at normal incidence is given by

$$\mathsf{M} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}.$$

Calculate the Mueller matrix of a mirror as a function of the rotation angle α around its normal. What is wrong and why?