

Spatial evolution of differential Mueller matrix in turbid media: a stochastic approach

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We show in this paper the existence of different regimes in spatial evolution of depolarization in turbid media characterized by a diagonal Mueller matrix (pure depolarizer). Experimental results previously published, already established the existence of a first regime where the depolarization follows a parabolic law with the thickness of stationary medium traveled by light [1-2]. New experiments firstly confirm the existence of a second regime which we have previously demonstrated [3-4] where the depolarization follows a linear law on a large scale. They also confirm the existence of much more complex evolution laws even under small-scale approximation. A stochastic approach is proposed to model the phenomenon. It perfectly describes all these different experimental results and allows to analyze the behavior of the polarization in the case of solid or liquid scattering media. Entries of the depolarizing differential Mueller matrix (*DDMM*) are associated to fluctuation of birefringence and dichroism properties. These fluctuations are described by a stochastic Orstein-Uhlenbeck process:

$$X(z) = e^{-a(z-z_0)} X_0 + \int_{z_0}^z \sigma e^{a(u-z)} dB(u)$$

where B stands for a Brownian process, a is a parameter specifying how strongly the system reacts to perturbations, σ is related to the amplitude of the perturbation and X_0 is the initial condition of the parameter at $z=z_0$. Under small-scale approximation the diagonal entries α_i of the *DDMM* are given by ($Var(X_0)$ stands for the variance of X_0):

$$\alpha_i = Var(X_0)z^2 + \left(\frac{\sigma^2}{3} - a \cdot Var(X_0) \right) z^3 \quad \text{with } 0 \leq Var(X_0) \leq \frac{\sigma^2}{2a}$$

Thus leading to changes that can continuously go from a parabolic behavior towards a cubic behavior depending on the value of $Var(X_0)$. This latter parameter can be related to the measurement setup and particularly to the numerical aperture used at the sample output for collecting light.

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