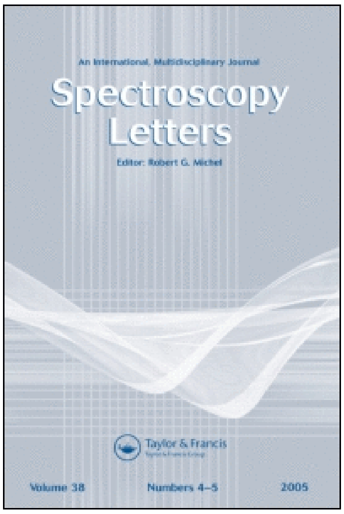

Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

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To cite this Article Grochowski, Lucjan(1977) 'Modelling of Light Polarization Measurement', Spectroscopy Letters, 10: 6, 417 — 421
To link to this Article: DOI: 10.1080/00387017708065496
URL: http://dx.doi.org/10.1080/00387017708065496

SPECTROSCOPY LETTERS, 10(6), 417-421 (1977)

MODELLING OF LIGHT POLARIZATION MEASUREMENT

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A model of light polarization measurement given by a general algorithm formed at the aim of coherency matrix formalism of electromagnetic wave is reported. There are shown the operations needed for measurement of any polarization state and control of measurement process at determination of physical quantities by means of polarization parameters.

The formal theory of measurement as has been developed in recent years has introduced the mathematical models describing the measurement procedure [1]. These models settle the sequence and interaction of measurement operations needed for determination of measured parameters. It enables to treat the measurement procedure on broad basis and to optimalize this procedure in any manner e.g. for receiving of best accuracy of measured quantities. Up to now, these models in polarization measurement are not used, however, more frequent use of the polarized light in different complex measurements, causes the need of their application.

The purpose of this paper is to form a main base for modelling of polarization measurements by the use of a coherency matrix formalism - rigorous but simultaneously compact description of any light polarization. It is realized by the introduction of a general algorithm of polarization measurement which sistematizes all possible cases of polarization and settles measurement operations.

Let the light polarization state be given by Wolf's coherency matrix [2]

$$J = \begin{pmatrix} J_{xx} & J_{xy} \\ J_{yx} & J_{yy} \end{pmatrix} \qquad (1)$$

which fully and uniquely describes any polarized wave as well as any unpolarized electromagnetic wave. And let the commonly used ratio of x,y electric field components $\tan\Psi = \left(\frac{J_{yy}}{J_{xx}}\right)^{1/2} = \frac{E_y}{E_x}$ and phase difference $\varepsilon = \delta_{E_y} - \delta_{E_x}$ be two parameters sufficiently describing completely polarized wave.

The accurate measurement of any polarization state is equivalent to determination of elements $J_{xx}, J_{yy}, J_{xy}, J_{yx}$ or at simplifie assumption of parameters Ψ, ε. However, the light polarization states are not observables, they are determined in the measurement by the derivate quantities. From the formal point of view it means that polarization measurement are the indirect measurements.

Using the mathematical formalism each measured polarization state $\underline{P}_i$, named further a measured object, can be treated as an element of the set consisting the same quantities which form the set of all polarization states

$$P = \{P_1, P_2, P_3 \ldots P_n \ldots\} \qquad (2)$$

In this set the polarization states are determined with accuracy of quasimonochromatic approximation caused by the real conditions of the measurement. The measurement of each state $\underline{P}_i$ resolves itself to the measurement of the derivate quantities of $\underline{P}_i$ - the light intensities which form the set

$$In = \{In_1, In_2, In_3 \ldots In_n \ldots\} \qquad (3)$$

Both sets in eq.(3) and (2) are equivalent, if the set $\underline{P}$ is uniquely mapped into set In, it assures the matrices product[2,3]

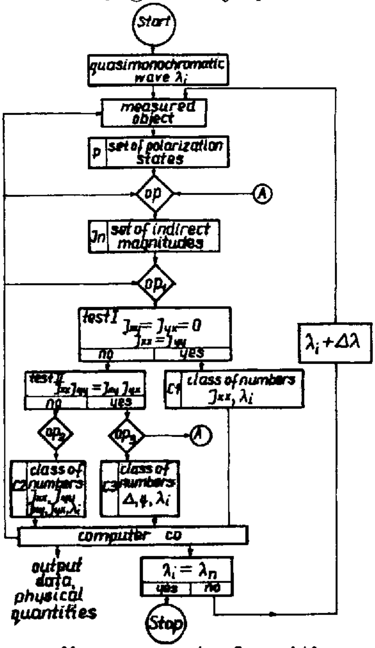
$$I(p,\varepsilon) = (\cos p \quad e^{i\varepsilon}\sin p)\begin{pmatrix} J_{xx} & J_{xy} \\ J_{yy} & J_{yy} \end{pmatrix}\begin{pmatrix} \cos p \\ e^{-i\varepsilon}\sin p \end{pmatrix} \tag{4}$$

makes the light intensities $I(p,\varepsilon)$ dependent on elements of coherency matrix for : p - the angle of light vibration with an assumed reference plane and ε - phase difference between x,y components of electric field.

Each group of four intensities $I(p,\varepsilon)$ which uniquely determine elements $J_{xx}, J_{yy}, J_{xy}, J_{yx}$ makes an element of the set $\underline{In}$. By this, for arbitrary quasimonochromatic wave, the set $\underline{P}$ of light polarization states is homomorphically mapped into the set $\underline{In}$ of light intensities. It is result of operation $\underline{op}$ accomplished in the optical subassemblies of corresponding instrument. Following this, the light intensities $\underline{In}_i$ are linearly changed into electrical signals in photodectors realizing the operation $\underline{op}_1$. The photodetectors are connected with electronic unit where the measured signals are subbmitted to further processing. There can be used two tests. The test I distinguishes the unpolarized light from partially and completely polarized light states; then are fulfiled the conditions : $J_{xy}=J_{yx}=0$ and $J_{xx}=J_{yy}$ for completely unpolarized light. The test II distinguishes partially polarized light waves from completely polarized waves and corresponds to conditions : $J_{xx}J_{yy}=J_{xy}J_{yx}$ for completely polarized light and $J_{xx}J_{yy} > J_{xy}J_{yx}$ for partially polarized.

If the light is partially polarized, the electrical signals corresponding to elements of coherency matrix are measured separately by the use of operation $\underline{op}_2$. Similarly, if the light is treated as completely polarized the parameters ψ, ε are measured by the use of the operation $\underline{op}_3$.

Using the operations op_1, op_2 and op_3, having the sense of different measurement methods, three classes of numbers are obtained : the class $C1$ given by quantities corresponding to J_{xx} describing unpolarized light, the class C2 given by quantities corresponding to $J_{xx}, J_{yy}, J_{xy}, J_{yx}$ and describing the partially polarized light, the class C3 given by quantities corresponding to ψ , $\mathcal{E}$ and describing



Measurement algorithm

the completely polarized light. These classes of numbers $C1, C2, C3$ identify each measured object - any polarization states although they have no physical interpretation by themselves. In many cases the knowledge of measurement results used to form these classes makes a final product of measurement, frequently yet, such measured parameters are utilized in further computer processing for determination of other physical quantities. Then, the computer is used on line for control measured procedure in operation op, op_1 and measuring conditions.

The presented above sequence of measurement operations were obtained for one wavelength λ_i . The measurement for optional different λ can be made similarly by the repetition of the same operations; for given spectral range these operations are performed for $\Delta\lambda$ from λ_i up to λ_n (if $\lambda_i < \lambda_n$).

The symbolic representation of the presented procedure can be described by

$$\langle P \, , op \, , In \, , op_{1,2,3} \, , C1,2,3,co \, , Ph \rangle \qquad (5)$$

expressing the number operations required for identification of measured object - the light polarization or the physical quantities Ph after computations co accomplished in the computer. The description forms an general algorithm of polarization measurement which is shown.

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