INTRODUCTION

Commercially available optical particle analyzers generally provide satisfactory results after adequate calibration with the particles in question. It is the purpose of this paper to point out, how the performance of optical particle sizers can be improved by polarization measurements.

The results presented in this paper are derived from multicolour laser experiments providing electrodynamic suspension of single dust particles. The size range of the particles is between 20 and 150 μm. For details of the equipment see Killinger et al. (1987, this volume).

The light scattering features of particles are closely related to their physical properties. Features addressed in this paper are the run of intensity, linear polarization and cross polarization vs scattering angle θ.

If the scattering signature is used for size discrimination, the most common application, it must be taken into account, that the scattering properties strongly depend on particle shape and composition, as well.

Basic connections between observed scattering features and physical properties of the particles are schematically summarized in the following Table 1. These connections will be illustrated by typical measuring results. It will further be shown, how polarization effects can be used for correct interpretation of particle counter and aerosol photometer measurements as well as for particle characterization and discrimination.
Table 1.

<table>
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<tr>
<th>QUANTITY MEASURED</th>
<th>TYPICAL FEATURES</th>
<th>CONNECTION WITH PARTICLE PROPERTIES</th>
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<tr>
<td>INTENSITY</td>
<td>ENHANCEMENT OF FORWARD SCATTERING</td>
<td>SIZE</td>
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<tr>
<td></td>
<td>ENHANCEMENT OF BACKWARD SCATTERING</td>
<td>SHAPE</td>
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<td>POSITIVE, NEUTRAL, OR NEGATIVE VALUES AT MEDIUM SCATTERING ANGLES</td>
<td>MATERIAL, SHAPE, STRUCTURE, SIZE</td>
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<td>CROSS POLARIZATION</td>
<td>RELATIVE MAGNITUDE OF CROSS POLARIZING ELEMENTS OF THE MUELLER MATRIX</td>
<td>MATERIAL, SHAPE, SIZE</td>
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</table>

FORMALISM

The scattering problem can be described proceeding from a linear transformation (see van de Hulst, 1957):

\[
\begin{bmatrix}
I_{s1} \\
I_{s2} \\
V_{s1} \\
V_{s2}
\end{bmatrix} = \frac{\lambda^2}{4\pi^2 r^2} \mathbf{A}_{ij} \begin{bmatrix}
I_{i1} \\
I_{i2} \\
V_{i1} \\
V_{i2}
\end{bmatrix}
\]

Index \( o \) of the Stokes vector characterizes the incident, index \( s \) the scattered radiation, respectively; indices 1 and 2 characterize the components polarized parallel or perpendicular to the scattering plane; \( \lambda \) is the wavelength; \( r \) is the distance between the scattering particle and the observer. The complete information of light scattering is contained in the 16 elements of the 4 x 4 Mueller matrix, each of which depends on the scattering angle \( \theta \). However, for a single particle in fixed orientation there are only seven independent matrix elements, which reduce to six for particles with symmetry plane in random orientation (Bohren and Huffman, 1983).

Although other elements also contain information about the particle (Perry et al., 1978, Bickel and Stafford, 1980, Bottiger et al., 1982), consideration of the elements \( A_{11}, A_{22}, A_{21}, \) and \( A_{22} \) is sufficient for the treatment of effects concerning total intensity, linear and cross polarization.

Based on these coefficients, the total scattered intensity is proportional to \( (A_{11} + A_{12} + A_{21} + A_{22}) = i \) (total scattering function).

The degree of linear polarization can be defined as

\[
P = \frac{(A_{22} + A_{21}) - (A_{11} + A_{12})}{A_{11} + A_{12} + A_{21} + A_{22}}
\]

Cross polarization is characterized by the elements \( A_{12} \) and \( A_{21} \). Their magnitude \( (A_{12} \equiv A_{21} \; \text{for random orientation}) \) relative to \( A_{11} \) and \( A_{22} \) provides a measure for the strength of cross polarizing effects.