

Classification of Single Particle Optical Scattering Patterns

G. F. Crosta

Università degli Studi Milano - Bicocca, Italy

Some experimental methods such as *TAOS* [1] are capable of collecting the light scattered by single airborne particles in the micrometer size range when the latter are illuminated by a triggered laser source (wavelength = 532 nm). Data consist of intensity patterns (Fig. 1) collected in a suitable solid angle at a high rate (>100 patterns per second).

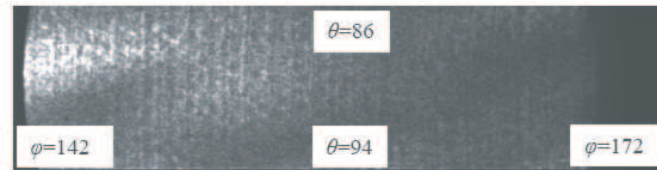


Figure 1.

Typical scattering pattern (*a07b03b*) produced by an aerosol particle from skid braking tests on a car racing track. Aerosol was collected by an 8-stage impactor device, re-suspended in water and injected into the *TAOS* apparatus.

There is no known theoretical method capable of determining the particle size, shape and complex refractive index from such incomplete data. As a consequence a heuristic algorithm was developed, which relies on spectrum enhancement for feature extraction and on principal components (*PC*) analysis for classification. Spectrum enhancement of an image includes spatial differentiation, possibly of fractional order, followed by non-linear transformations aimed at separating structure from texture. *PC* analysis maps each input pattern into a point in the *PC* space. The classifier was trained with the aim of maximizing discrimination between suitable sets of *TAOS* patterns e.g., those labelled 1 and 2 in Fig. 2. New sets of patterns e.g., those from skid braking aerosol particles (labelled 4), were then submitted to the classifier. The result is also displayed by Fig. 2. From the *PCs* of a given pattern one can estimate how much the shape of the particle deviates from the spherical one.

REFERENCES

1. Holler, S., S. Zomer, G. F. Crosta, Y.-L. Pan, R. K. Chang, and J. R. Bottiger, "Multivariate analysis and classification of two dimensional angular optical scattering (TAOS) patterns from aggregates," *Applied Optics*, Vol. 43, No. 33, 6198–6206, 2004.

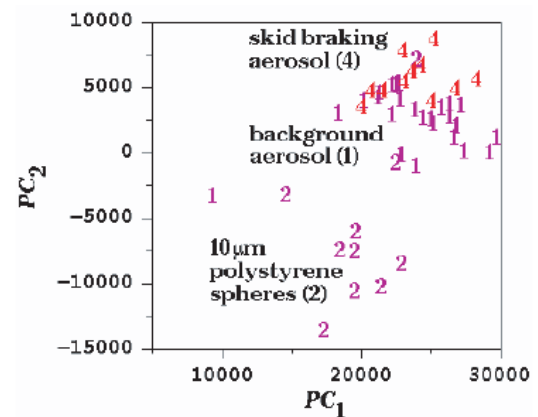


Figure 2: Classification of *TAOS* patterns from environmental aerosol particles: train on {1,2} → recognize {4}, $142.88432 < \varphi < 168.517815$, $86.083414 < \vartheta < 93.948435$, Exec = w05, $\delta = 45\text{deg}$, $p = 2.2$, $d + 1 = 10$, axis = u_1 , $0 \leq |u| \leq 255$, $\dim[\{PC\}] = 10$.