# Fourier-Bessel based Image Analysis for Multi-Parameter Particle Characterization

**Stijn Vandewiele, Oksana Drobchak, Filip Beunis, Kristiaan Neyts, Filip Strubbe**

Department of Electronics and Information Systems, Ghent University
Center for Nano- and Biophotonics (NB-Photonics), Ghent University

Email: Stijn.Vandewiele@elis.ugent.be
http://lcp.elis.ugent.be

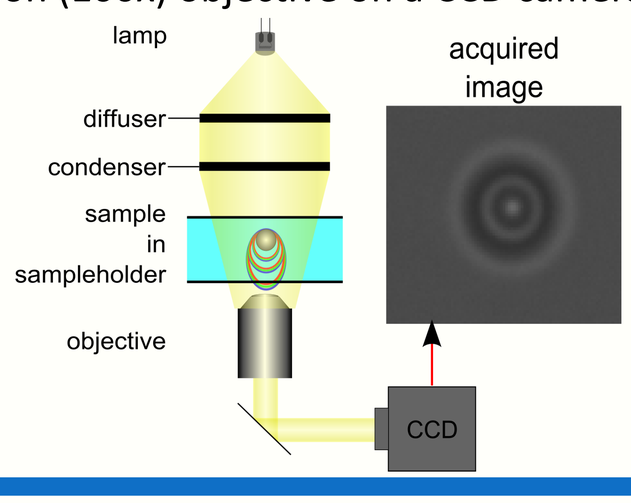
## Abstract

We demonstrate a novel particle characterization method based on decomposition of conventional microscopy images in Fourier-Bessel (FB) components. This allows the simultaneous measurement of size, refractive index, 3D position and orientation of single colloidal particles.

## Method

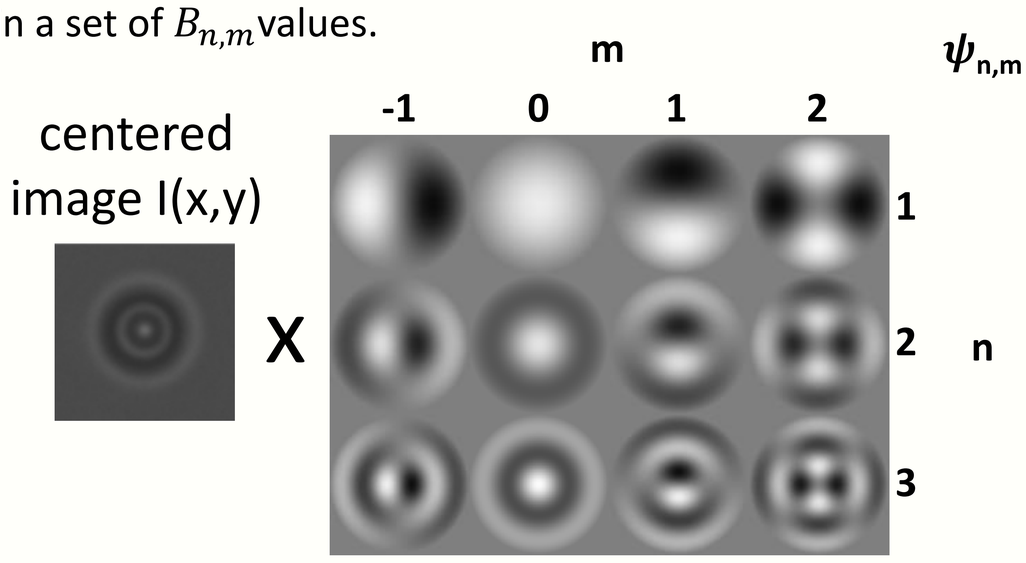
### Setup

A particle is illuminated with a white light source under a microscope. Scattered light is captured with a high magnification (100x) objective on a CCD camera.




### Image analysis

The centroid is tracked and the centered image is decomposed in Fourier-Bessel image moments resulting in a set of $B_{n,m}$ values.



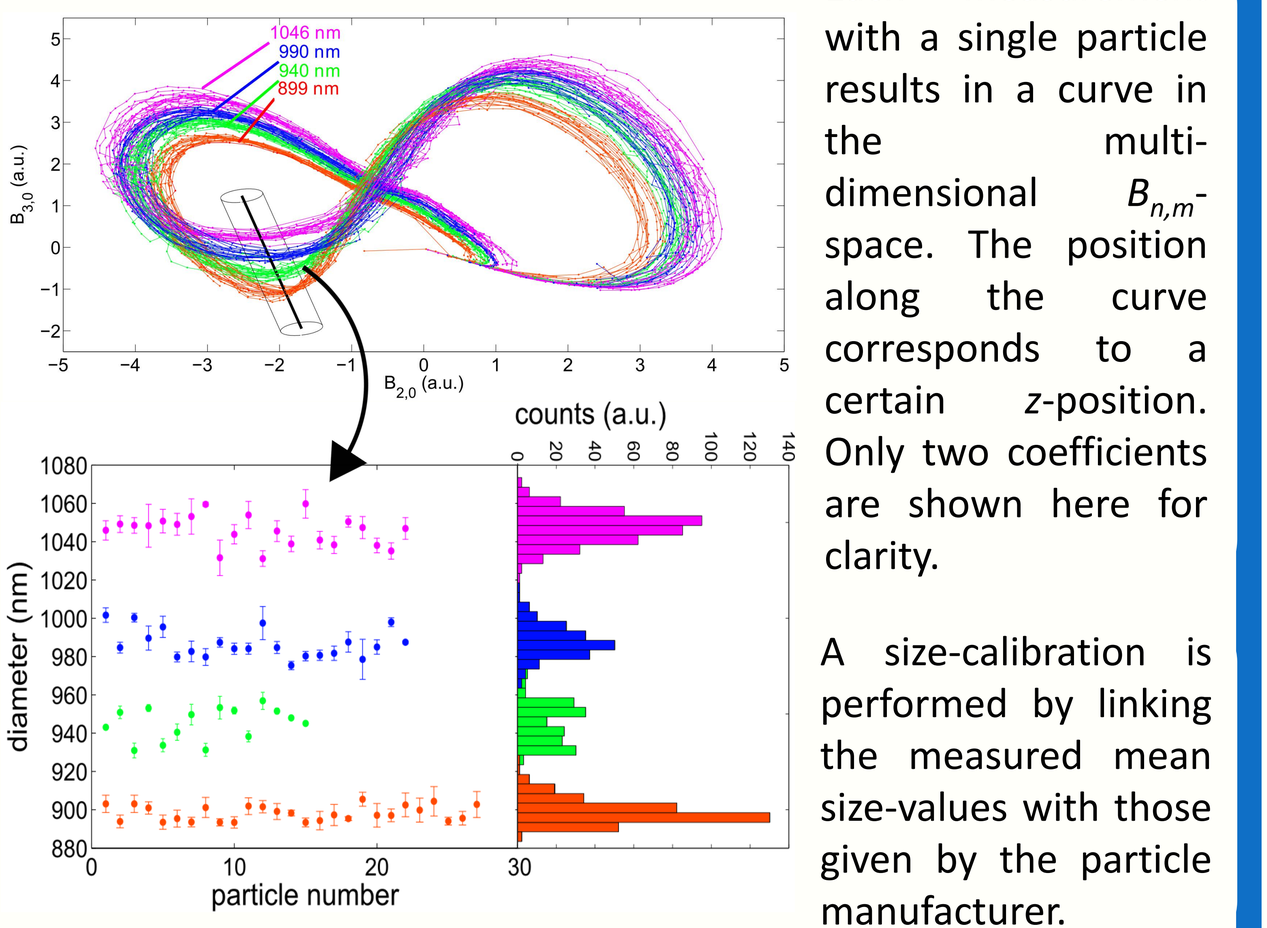

$$B_{n,m} = \int_0^a \int_0^{2\pi} I(r,\varphi)\psi^*_{n,m}(r,\varphi) r\,dr\,d\varphi$$

$$\psi_{n,m}(r,\varphi) = \frac{1}{\sqrt{2\pi N_n^{(m)}}} J_m\left(\frac{x_{mn} r}{a}\right) e^{im\varphi}$$

## Results

### Size extraction

Four different samples with monodisperse polystyrene particles ($d$ = 899, 940, 990 and 1046 nm) were characterized with the first 10 radial $B_{n,m}$ moments .




Each measurement with a single particle results in a curve in the multi-dimensional $B_{n,m}$-space. The position along the curve corresponds to a certain $z$-position. Only two coefficients are shown here for clarity.

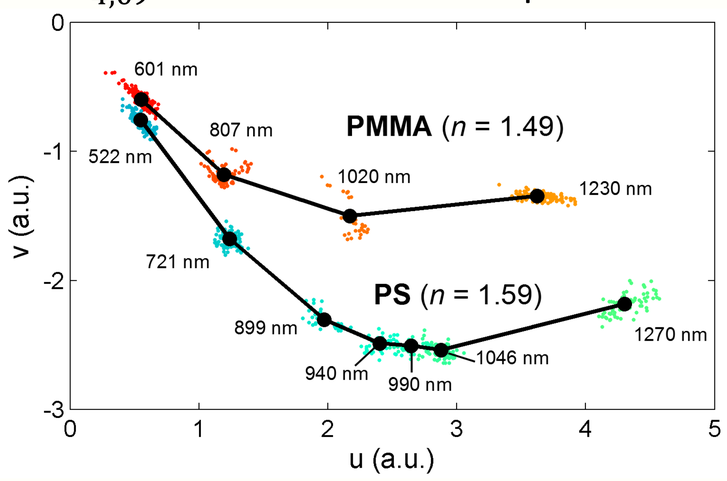
A size-calibration is performed by linking the measured mean size-values with those given by the particle manufacturer.

The measured standard deviation on the diameter per particle is ± 5 nm (≈1%). Results show that the four size distributions can be resolved well, which was not possible with Dynamic Light Scattering ($\sigma$ = 100 nm).

### Refractive index extraction

The refractive index (RI) is extracted by projecting three $B_{n,m}$ coefficients ($B_{2,0}$ , $B_{3,0}$ and $B_{4,0}$) on a well chosen plane with orthogonal basis $u$ and $v$.

Results show that the RI and diameter can be resolved simultaneously for PS and PMMA samples. The RI resolution is ± 0.0025 for $d$ = 1000nm.




## Conclusions

We conclude that the analysis using FB image decomposition can be used for simultaneous characterization of the size, refractive index and 3D position of single colloidal particles.

## Future prospects

In a next step we will demonstrate its applicability for tracking the orientation of non-spherical particles by including higher-order angular moments in the analysis. Additionally we will use this technique to measure local changes in RI of the medium.