Interactive comment on **'First correlated stereo imaging and polar scattering of cloud particles using PHIPS'** by A. Abdelmonem, M. Schnaiter, P. Amsler, E. Hesse, J. Meyer and T. Leisner.

Recommendation: The paper needs a lot of work before it is ready for publication, particularly with regards to several important issues listed below.

General comments :

This paper describes a new instrument which provides the simultaneous measurements of the particle shape (on two observation planes) and the corresponding scattering phase function of individual particles. This new and innovative technique has already been tested in the AIDA cloud simulation chamber during two campaigns with ice crystals formed between -5°C and -70°C. This instrument named 'Particle Habit Imaging and Polar Scattering', is the first step towards PHIPS-HALO which is part of the new probes that are currently developed for the new German research aircraft HALO. The PHIPS combines a stereo particle system using two identical devices for the imaging the same particle under an angular viewing of 60° and a polar nephelometer for the simultaneous measurement of a single scattering phase function. The setup, operation and detection system are first presented with the calibration of the imaging and polar scattering system. The data analysis and some results from the AIDA chamber are presented and discussed.

As a general point of view, the instrument performances and the results which are presented are convincing and promising. Nevertheless there are several aspects that should be discussed with more details or that are missing.

1/ Detection volume

The detection volume is a very important characteristic of the probe. The description of this volume is very difficult to understand from both the text and Fig. 2.

- For example, on page 5 the FOV = 0.76 mm whereas on page 8 FOV = 0.8 mm ??
- On Fig. 2, in addition to a perspective view of the detection volume, two perpendicular cross-sections would be very useful for clarity reasons with indications of pinhole diameter, laser beam diameter, FOV, DOF, ..
- What are the definitions of FOVh and FOVw ?
- How does the intersection between a cylinder of Aph/ 2 base area and FOV_w = 0.8mm height with a beam of *w*=0.5mm results in a quasi cylindrical detection volume ?

The citation of Schön et al. (2011) is inadequate here to explain the ratio ½.

- Is the detection volume for the stereo imagers the same for the scattering volume defined for the scattering measurements ? This is an important point to be presented with details because combined particle image information and scattering properties should address similar volume.
- More generally the two volumes should be clearly defined and mentioned with the evaluation of the probability that two or more particles (coincidence errors) could be present at the same time in the defined volumes and as a function of the particle concentration, the airspeed and the sampling rate.

2/ Polar nephelometer system

This system is poorly described regarding the sampling volume (see above) and the non-evaluated errors on the measurements due to the optical system design.

2.1 Astimatic errors

Due to the fact that the sampling volume has a finite size, the optical system is not stimatic. Therefore, a particle located outside the focal point in the sampling volume scatters energy following a certain angle which may not reach the corresponding detector. Numerical simulations could be made in order to evaluate the subsequent errors on the measurements. These simulations may use a ray tracing technique for the characteristic determination of the light beams which emanate from the sampling volume and reach one considered detector. For a given detector, the statistical distribution of the polar scattering angle provides information on the subsequent astigmatism error for each detector.

2.2 Reduction of the optical interferences

It is imperative to minimize the spurious reflected light from both the incident illumination and the scattered radiation and also to reduce the effects of outside light which may enter the optical chamber. On solution consists into the reduction of the cone-aperture of the detectors so that they can only be reached by the beams coming from the sampling volume. Are the fibers for angles from 1° to 10° located in a hole drilled into the detector array? The sink will therefore occult part of the scattered light. Otherwise, it is imperative to reduce the aperture of these detectors because of the (usual) large numerical aperture of the optical fiber (30° ?). How are housed the fibers for angles from 1° to 10° ?

2.3 Sensitivity of the scattering measurements

Nothing is indicated about the reliability of the scattering measurements performed at small forward angles (1° to 10°). How is removed the direct light from the laser beam. How are reduced the effects of diffraction near the edges of the laser beam and what are the order of magnitude (signal on noise ratio) of the offsets on the measurements ?

What is the minimum particle size which is expected to be measured with all scattering angles with the fibers ?

Calibrated and monodisperse glass beads (down to a few micrometers diameter) could be used to control and calibrate the instrument.

3. Calibration

How are calibrated the different channels in order to translate raw measurements to physical data (for instance sr-1 micrometer-1).

4. Choise of the laser type

The laser used for the Polar Nephelometer system (CrystaLaser, model CL532-300-L) has the coherence length of about 300 meters in the Single longitudinal mode, and about 0.5 - 3 mm in the Multiple longitudinal mode. In other words, the Spectrum line-width is very small, about 0.15 nm or less. Consequently, the angular scattering intensity of a single particle has a very strong oscillating component. Such oscillations are seen on the theoretical curves on Figures 4 and 14. The nature (origin) of the oscillation is the same as the nature of the interference Patterns (speckle structure) the authors mentioned in the first paragraph of the page 6. In such conditions it is impossible to obtain the calibration factors (page 9) or to model the measured data using the RTDF (page 20).

A more appropriate solution is to choose as a source a laser, which has the Spectrum line-width as large as possible. And, the theoretical curves used for calibrations and modelling MUST be averaged over the spectral interval of the laser source. (The power spectral density curve should be taken into account.). Such an averaging will smooth the angular scattering intensities of a single particle, i.e. the oscillations will be eliminated. Thus, it will be possible to obtain calibration factors or to model experimental data using the RTDF.

Minor comments :

The manuscript refers many times to the work by Schön et al. (2011). This is not comfortable for the reader, and some explanations should be useful to be recalled (see above).

Page 1: The title of the paper should be modified with the complete name of the instrument (not only the acronym). For example: The new Particle Habit Imaging and Polar Scattering (PHIPS) probe for the correlated measurements of the shape and scattering properties of cloud particles (or equivalent).

Page 1: Abstract: Same suggestion as above. The name of the probe should be first indicated rather than the acronym.

Page 3, line 20 : ASTAR not ASTRA

Page 5, line 28 : Add (see section 4.1.3), after … shown below.

Page 6, line 12 : PMMA acronym needs to be explained.

Page 6, line 26 : ACD acronym needs to be explained.

End of page 9 and Fig. 4: Some discussion should be useful for the comparison between the measured scattering function and the theory. Should a mean scattering function from numerous quasi-monodisperse particles more relevant for calibration purposes ???

Page 10, line 8 : Therefore …

Page 17, line 26 : Formulae X = 2a / L : Please use the same letters on Fig. 8 (i.e. H, W).

Page 20: The end of section 5.1 is not clear about the comments on comparisons of measurements with theoretical results. The observations should be reported on Fig. 13 to show differences between the two approaches.

Page 21: End of section 5.2 and Fig. 14. The scattering angle at 115° is strongly underestimated compared with theory. The theoretical model should used with small variations of the Euler angles in order to evaluate the sensitivity of the results.

Section 4.1.5 : Particle classification : Should be the object of an Annex.

Figure 10. Please re-write the legend with more concise details. What are the instruments shown on panels c, d, e and f, respectively ?