The Influence of Particles Outside the Size Range of the LISST

Sequoia, February 23, 2011

A question that Sequoia often gets asked is: What happens when the suspension contains particles outside the measurement range?

The short answer to this question is: Leakage. For those who are familiar with electronic filters, this is analogous to leakage of signals outside the filter pass-band. No filter is ever perfect – the cut-off is not sharp. Similarly, the size cut-off is not sharp for laser diffraction. To investigate the nature of cut-off, one can theoretically construct the scattering across the 32 LISST rings from particles *outside* the size range, then invert these scattering patterns in the normal manner.

Figure 1 below shows the scattering patterns on the 32 rings for particles that are LARGER than the upper size limit. The data are computed for a LISST-100X type C, but the conclusions to follow are the same regardless of the type of LISST. The scattering intensities are arbitrary values.

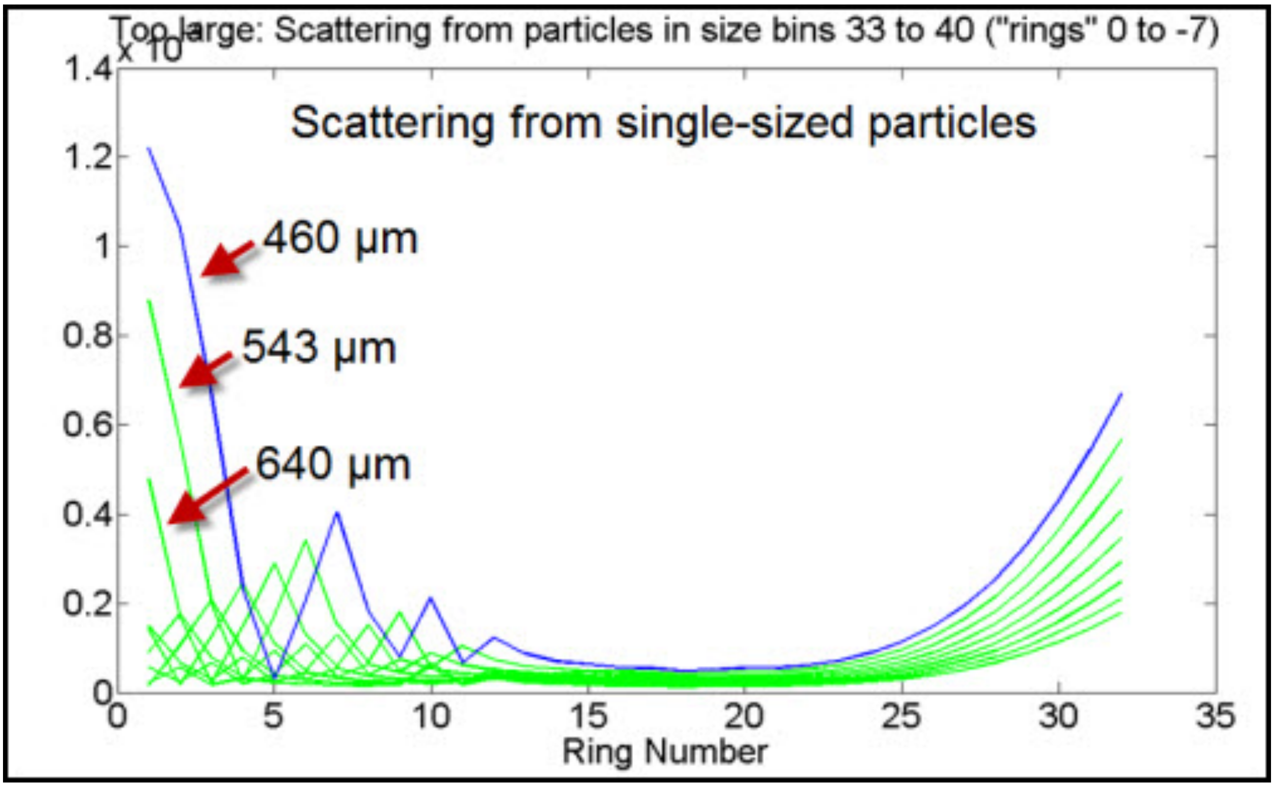

Figure 1: The blue curve is the scattering signature from single-sized particles with a size of 460µm (the mid-point of size bin 32 on a LISST-100X type C). The green curves show the scattering signatures on rings 1-32 from single-sized particles with sizes from 543µm (mid-point of size bin 33, or ring 0, if it existed) to 1731 µm (mid-point of size bin 40, or ring -7, if it existed).

What is clear from figure 1 is that the intensity of light scattering on the innermost rings drop off very quickly as particles gets larger. The intensity on ring 1 drops from ~1.2 to ~0.4 as the particle size increases from 460 to 640 µm.

Figure 2 below shows the scattering patterns on the 32 rings for particles that are SMALLER than the lower size limit.

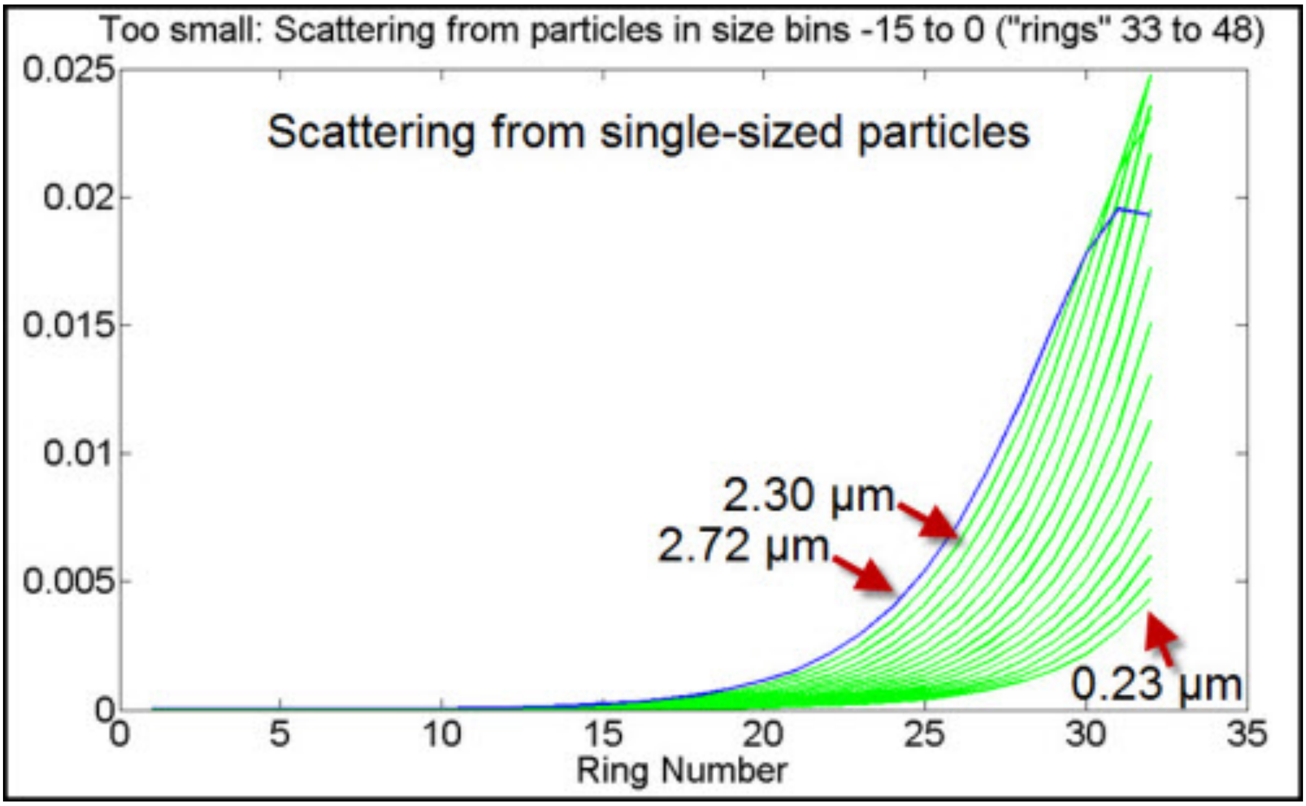

Figure 2: The blue curve is the scattering signature from single-sized particles with a size of 2.72 µm (the mid-point of size bin 1 on a type C LISST). The green curves show the scattering signatures on rings 1-32 from single-sized particles with sizes from 2.30µm (mid-point of size bin 0, or ring 33, if it existed) down to 0.23µm (mid-point of size bin -15, or ring 48, if it existed). The figure shows that the drop off in light intensity on the outermost LISST rings is much slower than the drop off for the large particles (cf. Figure 1).

When these scattering patterns are inverted to the volume distribution, the influence of particles outside of the size range on the LISSTs can be evaluated. This is done in figure 3, showing the response function in terms of volume for single-size particles across a wide size range. It is seen that the cut-off at the coarse particle end is sharp, i.e. particles much larger than twice the maximum size are strongly rejected. On the fine end, the cut-off is less sharp. Particles smaller by a factor 10 or more than the smallest size bins are rejected.

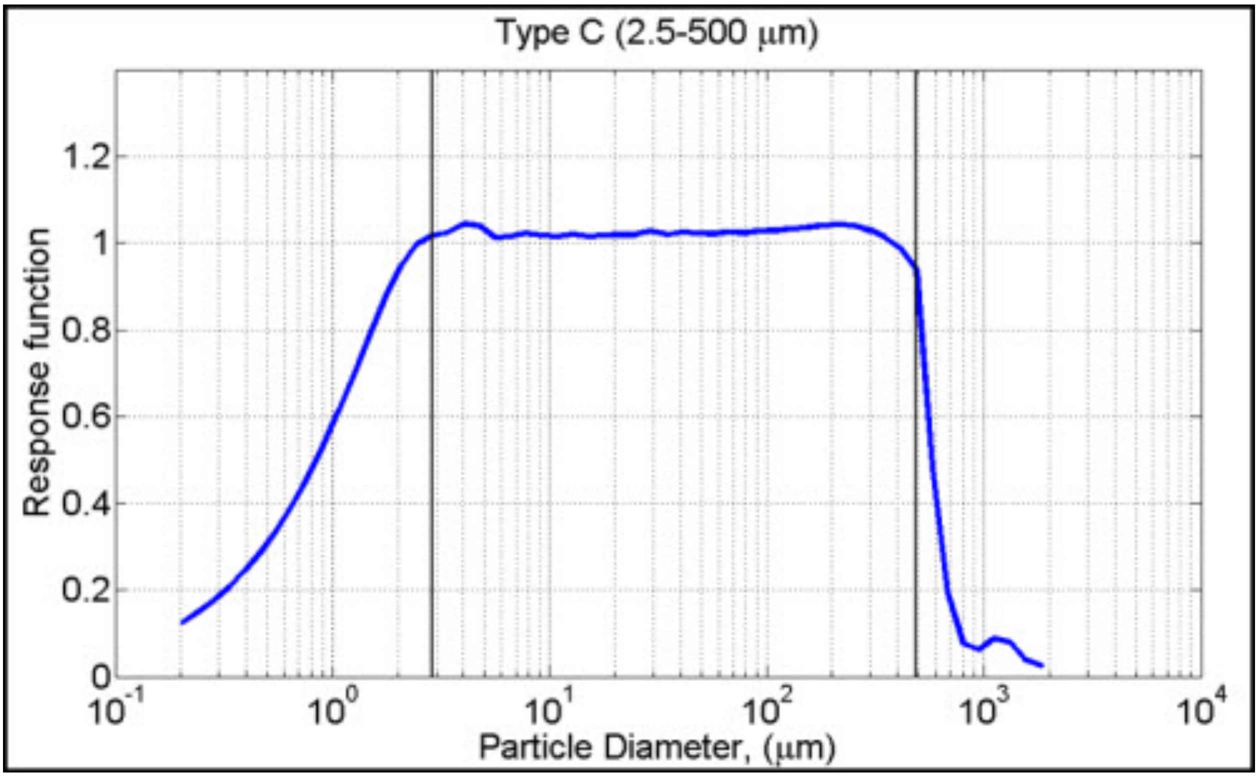

Figure 3: Measured concentration normalized by true concentration for a wide range of particle sizes, including particles outside the measurement range. [Mie theory based results.]

Because the small size drop off is gradual, leakage is more serious and this can often explain the rising tail at the small end of the particle size distributions. However, the LISST user should be aware that a rising tail at the fine end can also be due to non-spherical particles. A problem for which Sequoia has a unique solution.