

## Detailed Numerical Analysis of X-ray Phase Contrast Imaging in Sprays

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### Abstract

Recent studies of spray-related flowfields using synchrotron-based x-ray phase contrast imaging (PCI) have produced results that are sometimes straightforward to interpret in terms of the fluid structure, but in other cases the images do not reflect generally accepted physics of fluid motion. It has been unclear why some images have the appearance of a normal fluid stream while others depart significantly from expectation. The detailed numerical modeling presented in this paper is meant to explain the images and resolve common questions about the technique. The simulations show that collimated x-ray beams will always contain signatures from every possible encounter, from the input plane to the exit plane, and these signatures generate overlapping phase contrast patterns that can prove at times impossible to interpret. Clouds of moderate- to large-size drops produce a complex, mottled x-ray phase contrast image that cannot be interpreted. Small drops generate something akin to one gray pixel image each, and their size is close to the resolution limit of the instrument, so the diffraction pattern is broadened by the instrument response into something more like a small diffuse gray blob. Dense clouds of small drops produce a composite image that is a fairly uniform gray mass that cannot be interpreted. Moreover, we show that it is not possible to image intact liquid structures behind clouds of drops. Whenever a meaningful number of drops is present, therefore, x-ray phase contrast images are dominated by unavoidable artifacts of the technique.

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