

# 3D modeling of a population of particles from 2D silhouette images of two-phase flows.

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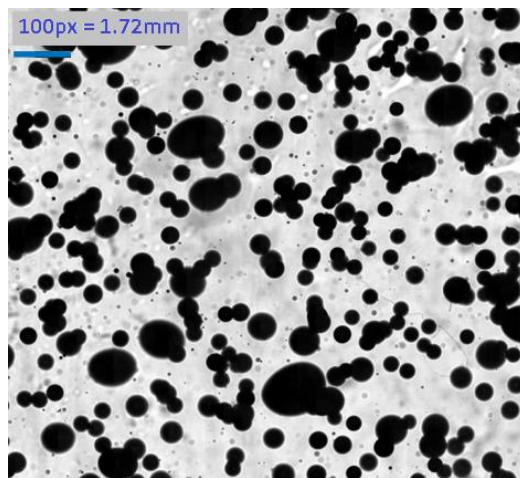
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## Abstract

In the research and development of nuclear fuel retreatment processes involving multiphase flows the characterization of bubbles, drops and solid particles is a key issue. Today, the extraction of spatial and geometrical characteristics of a particulate system is achieved mainly by either interferometric techniques (Sentis *et al.*, 2016) or image analysis techniques (de Langlard *et al.*, 2018). However, the automatic particles detection and 3D characterization remains a challenge for dense bubbly flows due to particle projections overlapping on the image (Figure 1).



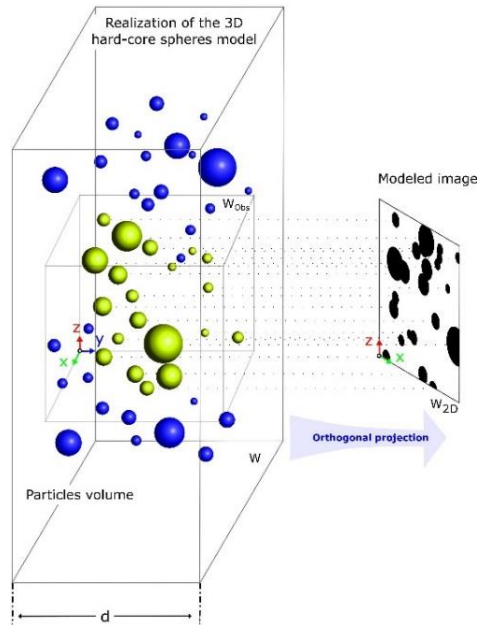
*Figure 1: Typical image of bubbly flow.*

Stochastic geometry models, and particularly marked point processes or germ-grain models (Chiu *et al.*, 2013; Kracht *et al.*, 2013), are promising approaches to address overlapping problem related to projection. Assuming that the particles are spherical or ellipsoidal, they can be modelled by a 3D marked point process and the obtained model can be fitted to experimentally acquired images.

In this communication an approach to describe 2D silhouette images – *i.e* image where only the union of the projections of opaque bodies are observed - of two-phase flows will be presented.

In a first part, populations of spherical particles (bubbles or droplets) will be considered in the aim of assessing the relevance of stochastic geometry for two-phase flows description. The proposed method lies in a 3D modeling of the population under study based on some

morphological and interaction assumptions. The considered 3D model is an adaptation of Matérn type II model (Matérn, 2013). Some important analytical properties of the proposed model will be presented. Then, orthogonal projections of the model realizations are made to obtain 2D modeled images, and these images are compared to the real images by means of the covariance and opening function. The inference technique we propose to determine the model parameters is a two-step numerical procedure: first a good initial solution of the parameters is sought, then, a classic optimization routine is used to find a local minimum in the neighborhood of the initial solution. We finally end up with a 3D model of spherical particles whose projections represent the true images of the two-phase flow, while capturing the information of interest. The 3D modeling approach is illustrated in Figure 2.



**Figure 2:** Representation of the silhouette image modeling. A 3D model of hard-core spheres is chosen and orthogonal projections of its realizations are constructed to model the silhouette images of two-phase flows.

In a second part, the generalization of the method to populations of ellipsoidal particles, typical of complex two-phase flows encountered in bubble columns, is discussed.

## References

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