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EXPERIMENTAL VALIDATION OF MODELS FOR RADIATION TRANSFER THROUGH SEMITRANSPARENT MEDIA CONTAINING LARGE GAS BUBBLES

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ABSTRACT. Many materials processing, bioprocessing, and manufacturing applications involve light scattering by non-absorbing spherical particles (e.g., gas bubbles) embedded in an absorbing medium. However, the Lorenz-Mie theory may not longer be applicable in such cases since it assumes that the medium surrounding the scatterers is non-absorbing. In the literature, several models predict the effective radiation characteristics of heterogeneous media consisting of bubbles embedded in a semitransparent medium. This study utilizes numerical, theoretical, and experimental methods to assess the validity and accuracy of these models. First, their predictions of normal-hemispherical transmittance and reflectance were compared with those obtained from the Monte Carlo ray-tracing (MCRT) method based on geometric optics for absorption coefficient of the continuous medium varying from 10^{-1} to 10^{2} m^{-1}. The models were then validated experimentally by comparing their predictions with measurements of normal-hemispherical reflectance and transmittance between 2 to 3 μm for a fused silica sample containing bubbles. A digital twin of the sample was constructed using a microCT scan to extract the exact location and size of all the bubbles to retrieve the bubble size distribution and volume fraction. Overall, the predictions by the hybrid model showed good agreement with those by the MCRT method as well as the experimental measurements. These results could be used for fast and accurate simulation of 1D radiation transfer through foams, liquids under bubbly flow as well as porous media.

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