Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Scale dependence of entrainment bubble size distribution in free-surface turbulence[1] XIANGMING YU, KELLI HENDRICKSON, DICK YUE, Massachusetts Institute of Technology — Air entrainment by free-surface turbulence plays important roles in both natural processes and engineering applications. We consider the size spectrum of surface entrained bubbles under strong free-surface turbulence (SFST) and develop a physical/mechanistic model for the entrainment bubble-size spectrum per unit interface area $\mathcal{N}_\rceil(\nabla)$. The model defines the spectrum dependence on gravity g, surface tension σ/ρ, and turbulence dissipation ϵ, and obtains two distinct entrainment regimes separated by bubble-size scale r_0. From the model we show that $r_0 = r_c = \frac{1}{2}\sqrt{\sigma/\rho g}$, the capillary length scale, and not the Hinze scale r_H as is generally assumed. For an air-water interface and earth gravity, $r_c \approx 1.5$mm. We confirm the theoretical model by high-fidelity, two-phase, volume-conserving direct numerical simulations (DNS) of a canonical SFST flow. We will present: (1) the respective power-laws of the two regimes; (2) the value $r_0 = r_c \neq r_H$; (3) the scaling of $\mathcal{N}_\rceil$ with g,σ/ρ and ϵ; and (4) confirmation of the $\epsilon - r$ entrainment regime map predicted by the model.

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Date submitted: 01 Aug 2019 Electronic form version 1.4