Dynamic Structure Factor and Correlation Time of Long-Range Density Fluctuations during Early Stage of Phase Separation from Direct Imaging

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The study of long time evolution of density fluctuations in pure fluids near critical point needs gravity-free experiments because they are affected by gravity since, among other properties, the compressibility of the fluid is very large near the critical point and the fluid compresses under its own weight. Experiments carried in microgravity have enabled new phenomena to be discovered as a result of the removal of convection, sedimentation and buoyancy phenomena. We present unique microgravity experimental results regarding thermophysical properties of sulfur hexafluride (SF_6) near critical point. Large density fluctuations were observed by illuminating a cylindrical cell filled with SF_6, very near its liquid-gas critical point ($|T-T_c| < 300$ microK) and recorded using a microscope with 3.1 microns spatial resolution and a video recorder. We used a dynamic structure factor algorithm for image processing in order to compute the dynamic structure factor, the correlation time of density fluctuations and thermal diffusivity of the fluid during the early stages of phase separation. The novelty of the image processing algorithm used in this paper is that the fluctuation image is defined as the difference between two normalized images a certain time interval apart. By covering a wide range of time delays, we were able to extract not only the dynamic structure factor S(q,t)T(q), but also the optical background B(q), and the correlation time of the density fluctuations. From the structure factor, we estimate a universality exponent of -0.35 +- 0.05 for the power law of clusters' growth during the early stages of phase separation below critical temperature. Based on the estimated correlation time of fluctuations, we also inferred the value of the thermal diffusivity coefficient. From the thermal diffusivity and known universal laws we estimate that value of critical temperature for SF_6.