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# Drop Coalescence Studies

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The objective of this experimental study is to understand the detailed mechanics of the coalescence of liquid drops. The experiments are being conducted in an immiscible acoustic levitator with degassed water as the most medium.

Typically, a quasineutrally buoyant drop to silicone oil mixed with bromobenzene is levitated close to the velocity node of the levitator. A second drop of the same liquid is introduced, and as it slowly seeks the same levitation position, the drops coalesce. Coalescence is delayed until the host film between drops is completely drained. Following coalescence, the excess surface energy in the coalesced drop is dissipated through shape oscillations.

The final events of film rupture followed by drop coalescence are rapid, and are photographically studied with high-speed video (1000 fps.). Laser-induced fluorescence technique is used to visualize the dynamics of host film drainage. The details of the coalescence mechanics will be presented.

# DROP COALESCENCE STUDIES

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## Introduction

The objective of this experimental study is to understand the detailed mechanics of drop coalescence. The main aspects of interest are: surface tension controlled coalescence dynamics, the dynamics of host film drainage, and the role of relative drop size. The experiments are being conducted in an immiscible acoustic levitator with degassed water as the host medium.

The coalescence studies are part of a more general investigation of the problem of collision and coalescence of drops being conducted at the Center for Microgravity Research and Applications (MRA) at Vanderbilt University. These experiments form a core ground-based support program for collision - coalescence and materials processing experiments being planned for future space flights. In addition, the ground-based work should provide an understanding of such basic issues as interactions of rain drops and the evolution and size distribution of natural and industrial aerosols.

## Experimental Technique

Figure 1 is a schematic of the set up for conducting coalescence experiments. The acoustic cell design and the levitation technique resemble that of Trinh and Wang (1982). The acoustic cavity is 13.4 cm X 13.4 cm in inside cross section and the driver transducer vibrating surface is 12.7 cm in diameter. The transducer is driven in its fundamental longitudinal resonance at 19.14 kHz, and the height of the water column is 11.8 cm.

To initiate the experiments, a quasi-neutrally buoyant drop of silicone oil (Dow Corning 510/100 cs) mixed with bromobenzene is first levitated near the pressure maximum closest to the top surface of the water column. A second drop of the same liquid is then carefully introduced, and as it slowly seeks the same levitation position, the drops coalesce. Coalescence, one initiated, proceeds rapidly and is photographically studied with high-speed video (Kodak Ektapro 1000) at 1000 frames per second.

## Results

The presence of the host film between drops is a barrier to coalescence. Coalescence is delayed till the film is completely drained. since very low acoustic force is used in drop levitation, the film drainage is slow. At a certain critical film thickness, the film suddenly ruptures and the two drops contact and coalesce. The mechanism of film rupture is yet to be understood.

Equal size drops. Figure 2 (a-h) depicts the coalescence, initiated just following film rupture, of two drops of almost the same size (one drop seeded with aluminum tracers). As the two drops contact (Figure 2a), the lost surface energy appears as kinetic energy driving the coalescence rapidly. The coalescence front is planar (Figure 2 b,c,d) and there is no mixing induced during the coalescence process. The excess surface energy in the coalesced drop is dissipated through shape oscillations (Figure 2 e-h). Marston and Goosby (1985) have analyzed the damped shape oscillations of a drop in an immiscible system and, using their derivation for drop oscillation frequency, one can determine the surface tension of the coalesced drop.

Unequal size drops. Figure 3 (a-h) depicts the coalescence of two drops of diameter ratio 1.7:1.These pictures depict the cross section of the coalescing drops which is made visible by seeding the drops with a fluorescent dye and illuminating with a thin Argon ion laser sheet. The smaller drop is partially engulfed (Figure 3 a-e) by the larger drop and the shape oscillations of the coalesced drop are dominated by mode 2 oscillations (Figure 3 g,h). For higher diameter ratios, the engulfing is more a local shape perturbation on the larger drop.

## Future Work

Currently, efforts are being directed towards using laser-induced fluorescence technique to study the host film drainage and rupture. It is not clear whether films drainage is uniform and that coalescing surfaces remain parallel up to rupture as assumed by Foote (1971) and others in their analyses. The film could very well be unstable to random surface perturbations; this issue needs to be resolved. If necessary, interference techniques will be employed to make film thickness measurements.

## References


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Marston, P.L. and Goosby, S.G., Physics of Fluids, vol. 28 (5), pp. 1233-1242, 1985.

Trinh, E. and Wang, T.G., Journal of Fluid Mechanics, Vol. 115, pp. 453-474, 1982.

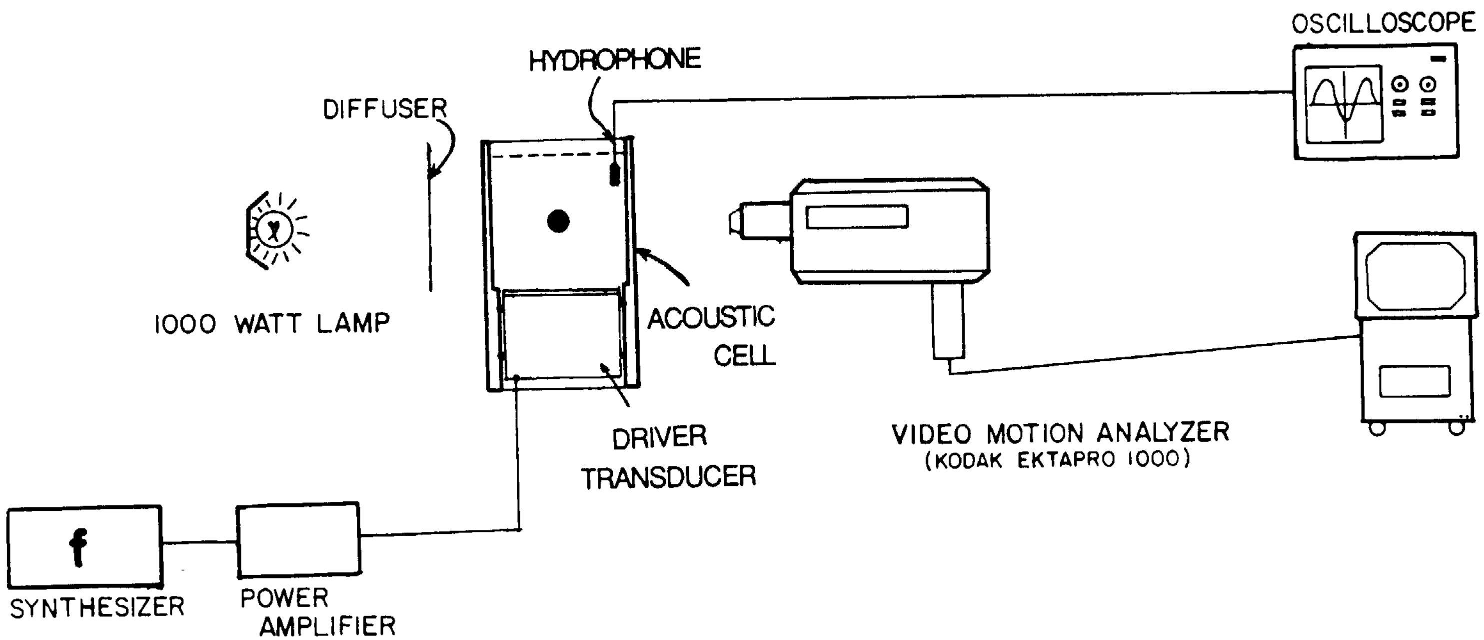
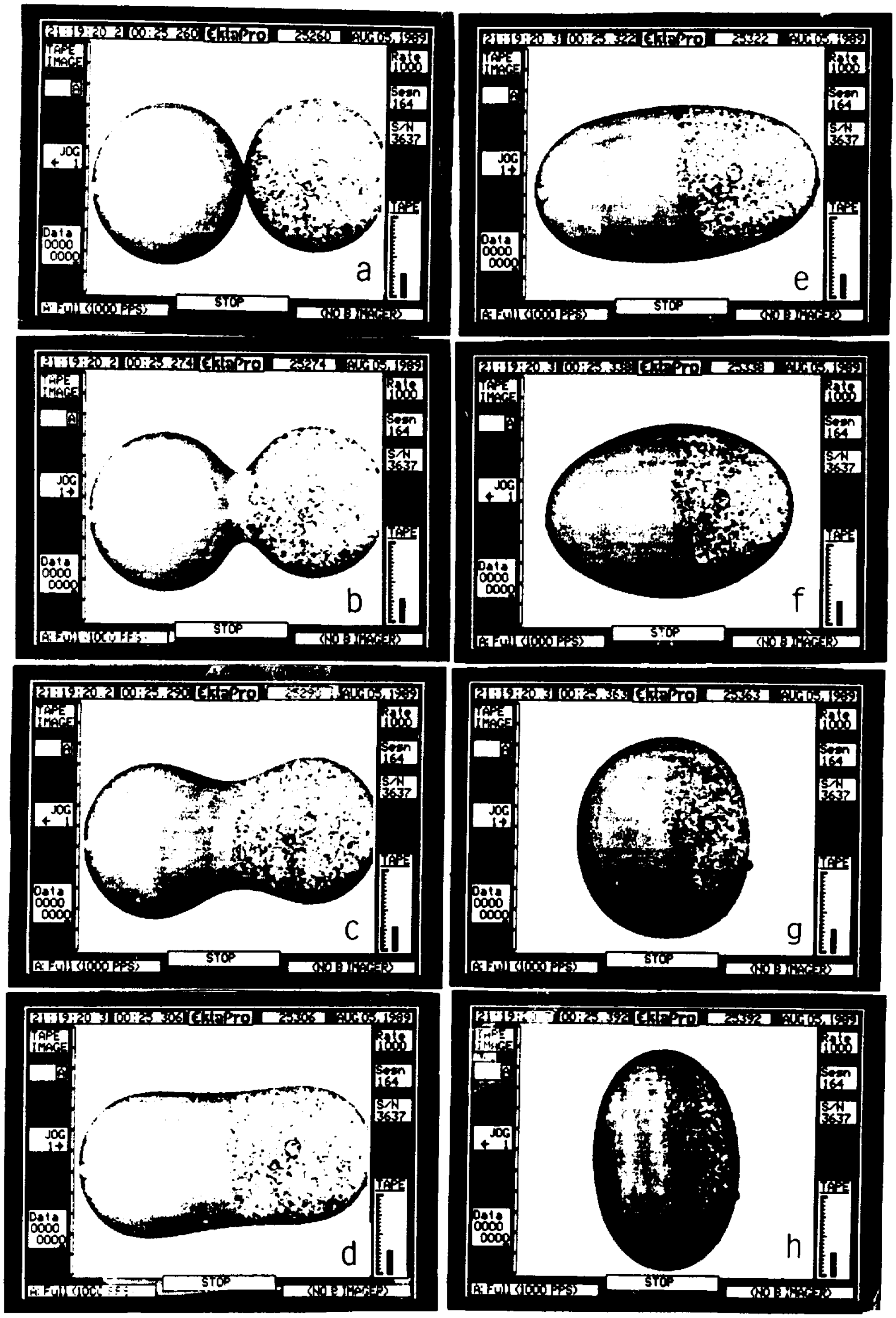



FIG. 1: EXPERIMENTAL SET UP (Schematic)




# FIG. 2: COALESCENCE AND OSCILLATION

(Equal Size Drops)



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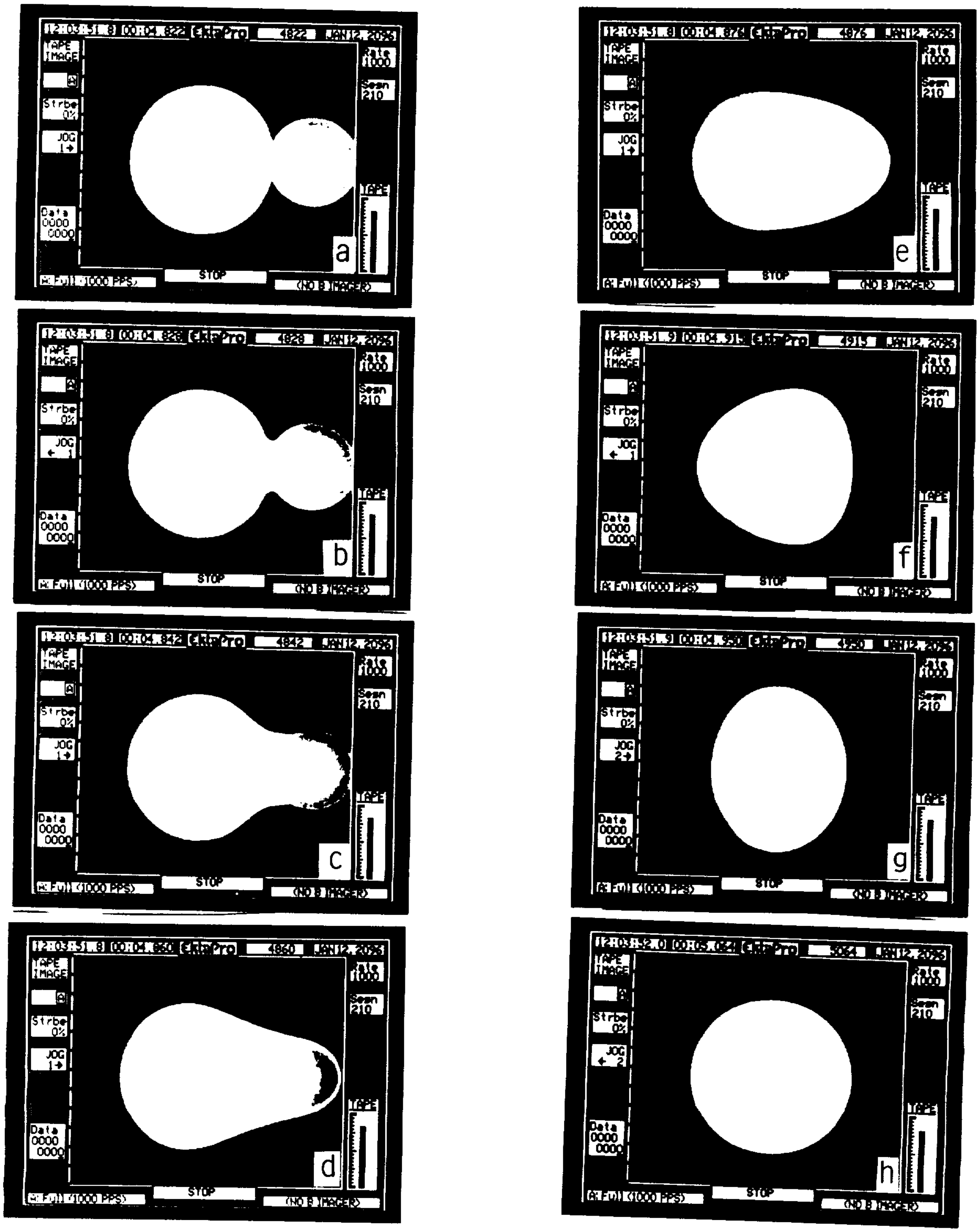


FIG. 3: COALESCENCE AND OSCILLATION
(Unequal Size Drops)

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