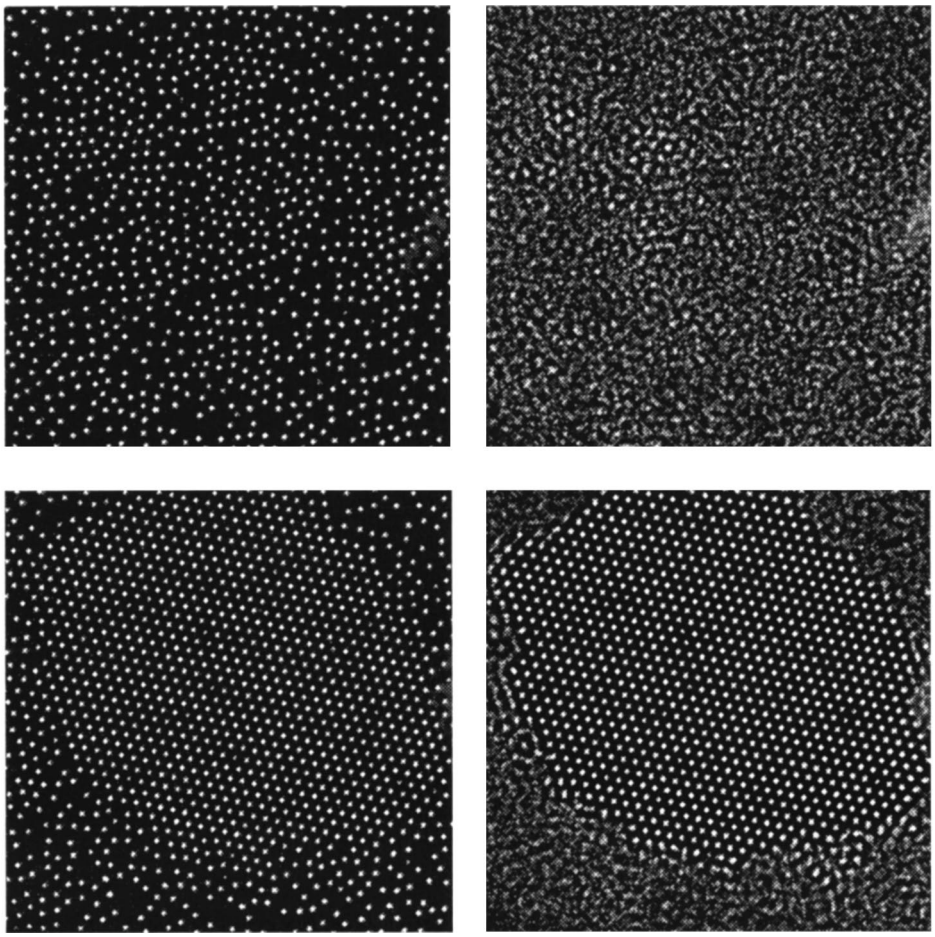

FIG. 1. Instantaneous images (left column) and composite images (right column) of a 2D driven granular layer as viewed from above. Upper left: Instantaneous image when $\Gamma=0.78$. Upper right: Bright peaks in the composite image at $\Gamma=0.78$ denote clusters. Lower left: Instantaneous image of collapse at $\Gamma=0.76$. Lower right: Composite image of the collapse demonstrates the two-phase behavior.

CRYSTALLIZATION IN A 2D GRANULAR FLUID

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Theoretical investigations into the dynamics of freely cooling granular media predict instabilities of the collective motion, such as clustering and collapse, as energy is lost via interparticle collisions.[2,3] Instantaneous and composite images demonstrate this behavior for a 2D gas in an experiment comprised of $N=8000$ uniformly spherical stainless steel particles that constitute a coverage of $\rho=N/N_{\max}=0.463$ on a vertically shaken plate near a peak acceleration of 1 g at a frequency of 70 Hz.[4] The dimensionless acceleration may be defined as $\Gamma=A(2\pi\nu)^2/g$, where g is the acceleration due to gravity and A is the amplitude of the plate displacement.

A camera positioned above the plate captures the nearly 2D behavior of the system. A diffuse light source illuminates an area of approximately one half of the upper surface of each particle. Movies demonstrate the dynamics more clearly.[5] Characteristic images are shown in the figure. The layer is initially fluidized at $\Gamma=1$. By slowly lowering the acceleration, the medium may be cooled while remaining near the steady state. At $\Gamma=0.78$, nonuniform density distributions in an instantaneous image (upper left) and nonuniform pixel intensities in a 1 s composite image (upper right) are a consequence of clustering in the system. A cluster then becomes the nucleation point for collapse when the acceleration is decreased to $\Gamma=0.76$ (lower left). The collapse is the ordered condensate of particles that are in contact with each other and the plate and remain motionless while the surrounding particles continue in a gas-like phase at reduced density. This is demonstrated in a 1 s composite image (lower right). The two-phase behavior will persist as long as the driving is maintained. To refluidize the condensate, the plate's acceleration must be slightly increased to $\Gamma=0.80$.

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