Space-time measurements of the influence of pinned contact line on the dispersion relation of gravity-capillary waves

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Surface wave dynamics may have a non negligible influence of edge constraints when the size of the container is in the order of a few centimeters and when the surface displacement is in the order of a few millimeters [1]. In these configurations the dynamic of the contact line, as has been widely explored theoretically and experimentally in the last decades, modifies the damping and the eigenfrequency of the system. By presenting a new approach, which combines a theoretical model with a fully space-time resolved measurement of the surface deformation and static meniscus, we estimate accurately the modification of the dispersion relation due to the additional force exerted by the contact line. The surface deformation and the static meniscus are measured using Fourier Transform Profilometry (FTP), from which we obtain a linear wave field that we decompose later onto transverse modes satisfying the condition of pinned contact line. The transverse modes decomposition, whose convergence we verified experimentally, is used in the calculation of eigenfrequencies for a given wavenumber. By varying the channel width, and exploring systematically the forcing frequency, we observe the modification of the dispersion relation due to the influence of the pinned contact line. Regarding the boundary conditions, two types were tested: a hydrophobic bare wall which pinned the contact line (Fig. $1a-b$), and a wire-mesh generating hemiwicking state that allows easy slipping of the contact line (Fig. $1c-d$). An effect inversely proportional to the channel width is observed in the pinned case while no modification of the dispersion relation was observed in the slipping case, being independent of the channel width. The experimental results reveals how the additional restoring force that the pinned contact line exerts, together with the gravity and the surface tension, is able to speed-up the traveling wave, increasing its phase velocity [2].

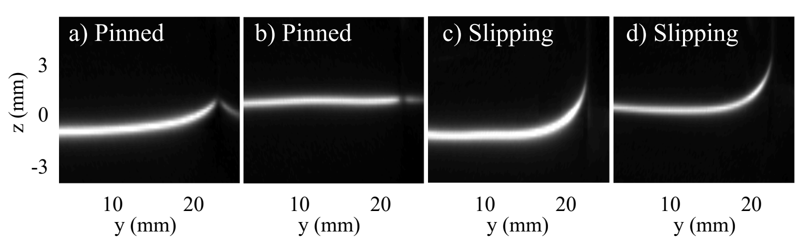

Figure 1. a) Wave trough with pinned contact line, b) Wave crest with pinned contact line c) Wave trough with slipping contact line and d) Wave crest with slipping contact line

References

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2. E. Monsalve, A. Maurel, V. Pagneux, and P. Petitjeans. Space-time-resolved measurements of the effect of pinned contact line on the dispersion relation of water waves. *Physical Review Fluids*, 7(1), 014802, 2022.