Comment on "Self-Affine Fractal Interfaces from Immiscible Displacement in Porous Media"

In a recent Letter[1] Rubio, Edwards, Dougherty, and Gollub reported their experimental results on the structure of interfaces in wetting immiscible viscous flows in porous media. They found that the interface roughness or width $w(L)$ of the water-air interface advancing in a thin layer of glass beads scales as $w(L) \sim L^{\beta}$, where $w(L)$ is defined as the rms value of the fluctuations of the surface over a length scale L, and β is an exponent[2] which characterizes the roughness of the interface. Their work is particularly important because it represents the first determination of β in an experimental system which is closely related to extensively studied computer models.

The conclusion of Rubio *et al.* is that β is quite insensitive to the experimental details and might represent a characteristic value for a class of surface growth processes. Although some of the related simulations[3] seem to lead to values of β close to the one obtained by Rubio *et al.*, their estimate $\beta = 0.73 \pm 0.03$ is significantly different from $\beta = 0.5$ which is known to correspond to various deposition models based on aggregation of particles.

The precise value of β and the length scale over which the scaling behavior can be observed in the experiments is crucial when making comparison with theoretical or computer-simulation results. For this reason, we reanalyzed the data shown in Fig. 1 using the same method which was described in the paper. We digitized the series of typical interfaces displayed in the abovementioned figure with a resolution 740×600 and calculated the surface width for each curve as a function of the length L of the samples representing different parts of the interface.

The result of our calculations are presented in Fig. 1. The main point of our Comment is that Fig 1 leads to an estimate $\beta = 0.91 \pm 0.08$, where the error is the standard deviation in the measured slopes. This result is clearly inconsistent with the above quoted value of β given in Ref. 1.

We were so puzzled by the discrepancy that we carried out the following procedures to double check our conclusion. First, the algorithm for calculating the surface roughness was used to obtain β for the restricted growth model[4] of Kim and Kosterlitz on system sizes corresponding to the experimental data. The surfaces obtained in the course of the simulation were plotted and digitized using the same method that was employed for the evaluation of the experimental data of Rubio *et al.* We obtained $\beta = 0.49 \pm 0.05$ in full agreement with independent theoretical and simulation results. This fact supports that our analysis yields correct estimates of β.

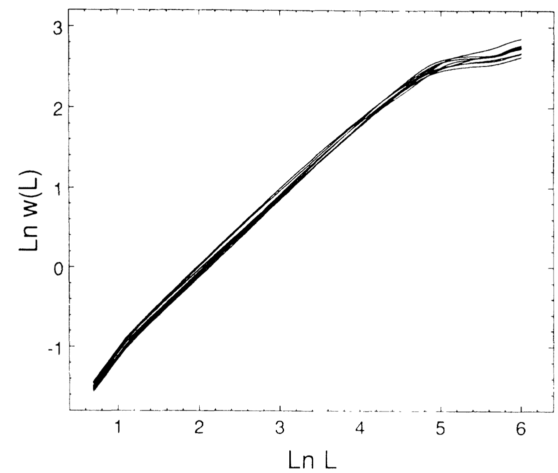

FIG. 1. Dependence of the surface roughness $w(L)$ on the length scale L calculated for nine successive interfaces plotted in Fig. 1 of Ref. 1.

The next test was provided by carrying out experiments analogous to those described in Ref. 1. In our experiment the same method of analyzing the interface gave $\beta = 0.88 \pm 0.08$. This value is very close to what we obtained for the surfaces published by Rubio *et al.*, but is different from their estimate.

In conclusion, the value and the error bar given in Ref. 1 for the exponent β is in significant disagreement with our calculations for the same quantity. The actual value of β is of particular importance because it is expected to be relevant from the point of view of universality classes of surface growth phenomena. Our results, as well as those published in Ref. 1, leave the above question open.

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