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Computer-based simulation for a new educational approach to surface tension phenomena

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Abstract. An educational approach to the surface tension concept, founded on a novel mesoscopic model of liquid, is presented here. We discuss in some detail the mesoscopic model and show semi-quantitative results obtained by a computer simulation implemented through the Smoothed Particle Hydrodynamics method.

1 Introduction

The traditional educational approaches to surface phenomena are often based on a macroscopic description of forces acting at interfaces and, sometimes, on a microscopic interpretation. Besides being sometimes incorrect or inconsistent, both approaches often prove to be ineffective in captivating both high school and undergraduate students and fostering an authentic understanding of the physical content [1].

The general aim of our research is to build and test alternative strategies to improve the teaching-learning process related to surface phenomena, also by the use of a novel mesoscopic model of liquid. Models built at an intermediate scale (i.e. mesoscopic scale) are recognized in the literature as useful to effectively introduce concepts like surface tension in educational contexts [2]. These models have the advantages of the microscopic one, but they do not require a lot of computational resources to successfully run the simulations implementing the models. So, teachers/students can simulate large portions of liquids by using computers commonly available in school laboratories.

Here we present some computer simulation results of our mesoscopic model of liquid. The simulations have been designed so that students can manage them by simply controlling some relevant parameters of the model.

2 The model

In the mesoscopic model we present, the liquid is composed of particles whose size is much bigger than that of a molecule (particle radius can be equal to a fraction of a millimetre). The interaction forces acting between mesoscopic particles have the same properties as the forces between microscopic particles. They are attractive at large distances and repulsive at short distances. The value of this force depends on the two interacting particles (liquid-liquid or solid-liquid) and on the inter-particle distance.

3 Simulations results

At the equilibrium, the pressure inside a liquid droplet depends on the surface tension and droplet radius according to the Young-Laplace law. We simulate the formation of a two-dimensional liquid droplet without gravity and obtain its surface tension.

We also study the liquid capillarity as a function of the liquid-liquid and liquid-solid interaction intensity by simulating a liquid in a tray with a capillary tube inside. At the equilibrium, we observe the formation of menisci and the rise of liquid under the effect of gravity. The simulations results highlight the forces acting on the SPH particles and allow us to estimate the value of surface tension.

4 Discussion and conclusions

Simulative activities require high mindfulness of the students, and problem-solving and decision-making skills are fundamental to run the simulation. By step by step analysing how the parameters related to inter-particle interactions affect liquid behaviour, the students may have the opportunity to focus on the mechanism of functioning underlying the observed phenomena. Simulations ran and studied this way can help students to understand the importance of models building process and to learn how to use a model to predict results starting from testable hypotheses.

The simulation activities we designed are part of a teaching/learning sequence that also includes extensive hands-on and minds-on experimental activities and interactive lessons based on active learning strategies. We are planning to trial the sequence with a specific sample of high school students and accompanying teachers.

References

[1] M. V. Berry, The molecular Mechanism of Surface Tension, Phys. Educ., 6 (1971) 79-84.

[2] U. Besson, L. Viennot, Using models at the mesoscopic scale in teaching physics: Two experimental interventions in solid friction and fluid statics, Int. J. Sci. Educ., 26 (2004) 1083-1110.

Primary authors: Dr BATTAGLIA, Onofrio Rosario (Dipartimento di Fisica e Chimica - Emilio Segrè, Università degli Studi di Palermo); Prof. AGLIOLO GALLITTO, Aurelio (Dipartimento di Fisica e Chimica - Emilio Segrè); Ms TERMINI, Giulia (Dipartimento di Fisica e Chimica - Emilio Segrè, Università degli Studi di Palermo); Prof. FAZIO, Claudio (Dipartimento di Fisica e Chimica - Emilio Segrè, Università degli Studi di Palermo)

Presenter: Dr BATTAGLIA, Onofrio Rosario (Dipartimento di Fisica e Chimica - Emilio Segrè, Università degli Studi di Palermo)

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