
Contribution ID: **617** Type: **Oral Presentation**

# A study of a non-equilibrium model with relative permeability hysteresis in two-phase water-oil system

*Wednesday, 24 May 2023 14:45 (15 minutes)*

Non-equilibrium modeling is relevant in several physics of coupled processes, flow and transport of fluids situations in homogeneous and heterogeneous porous media systems, for instance, subject to phase transitions, hysteresis and chemical reactions, among many others complex systems (see, e.g. [1,3,4,5,6] and the references cited therein). To model the dynamics of these phenomena, the corresponding system of partial differential equations typically incorporates source terms. In this work, we are interested in analytical and computational modeling of situations for which we connect states in equilibrium, but we allow that the change of physical situation presents a non-equilibrium relaxation time. We discuss the 1D-2D behavior of the wave groups of solutions in non-equilibrium situations for a two-phase water-oil model with hysteresis in relative permeability in porous media [5,6], generalizing the previous 1D results in homogeneous medium [1] for 2D flows, in heterogeneous porous medium, linked to a two-phase water-oil system [2]. This nonlinear phenomena is given by a coupled set of time-dependent partial differential equations of hyperbolic-parabolic-elliptic mixed type. We also consider synthetic spatial multiscale models of permeability and porosity that resemble the geological properties which control fluid flow. The computational 2D non-equilibrium solutions are obtained based on a sequential operator splitting approach supported by the relaxation projection method introduced in [1]. The main ingredients to obtain these solutions are shock, rarefactions and bifurcations [1,2]. We present 1D-2D solutions and discuss the nonlinearity interplay between wave structure of such solutions in non-equilibrium situations and the high-contrast heterogeneity in porous medium.

Keywords: Non-equilibrium models; Two-phase flow; Porous media; Relaxation relative permeability hysteresis; Analytical-computational methods.

## Participation

In-Person

## References

[1] E. Abreu, Bustos, P. Ferraz and W. Lambert (2019). A relaxation projection analytical-numerical approach in hysteretic two-phase flows in porous media. Journal of Scientific Computing, 79(3), 1936-1980.

[2] E. Abreu, P. Ferraz and W. Lambert (2022/2023), A nonlinear study of non-equilibrium wave groups with hysteresis in porous media, submitted.

[3] E. Abreu, A. Bustos and W. J. Lambert (2018), Asymptotic Behavior of a Solution of Relaxation System for Flow in Porous Media. In: Klingenberg C., Westdickenberg M. (eds) Theory, Numerics and Applications of Hyperbolic Problems I. HYP 2016. Springer Proceedings in Mathematics & Statistics, vol 236. Springer, Cham.

[4] E. Abreu, A. Bustos and W. J. Lambert (2015), Non-monotonic traveling wave and computational solutions for gas dynamics Euler equations with stiff relaxation source terms. Computers & Mathematics with Applications 70, 2155-2176.

[5] E. Abreu, A. Bustos, P. Ferraz and W. Lambert (2015), A computational multiscale approach for incompressible two-phase flow in heterogeneous porous media including relative permeability hysteresis. Proceedings of

the 6th International Conference on Approximation Methods and Numerical Modelling in Environment and Natural Resources Pau - MAMERN VI2015. Editorial Universidad de Granada vol. 1, 349-366.

[6] E. Abreu and W. Lambert (2012). Computational Modeling Technique for Numerical Simulation of Immiscible Two-phase Flow Problems Involving Flow and Transport Phenomena in Porous Media With Hysteresis. The American Institute of Physics Conference Proceedings Porous Media and its Applications in Science, Engineering and Industry, 1453, 141-146.

## MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

## Country

Brazil

## Acceptance of the Terms & Conditions

Click here to agree

## Energy Transition Focused Abstracts

**Primary authors:** Prof. ABREU, Eduardo (University of Campinas, Sao Paulo, Brazil); Dr CUNHA FERRAZ, Paola (Brazilian Synchrotron Ligth Laboratory); Prof. LAMBERT, Wanderson (UNIFAL)

**Presenter:** Prof. ABREU, Eduardo (University of Campinas, Sao Paulo, Brazil)

**Session Classification:** MS07

**Track Classification:** (MS07) Mathematical and numerical methods for multi-scale multi-physics, nonlinear coupled processes