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Contribution ID: **287** Type: **Poster (+) Presentation**

A macroscopic two-length-scale model for natural convection in porous media driven by a species-concentration gradient

Wednesday, 2 June 2021 10:00 (1 hour)

Turbulent natural convection in porous media has received increasing attention in recent years, especially due to its significance in emerging engineering applications, such as the long-term storage of CO_2 in deep saline aquifers or thermal-energy storage systems. Macroscopic equations are usually solved to calculate natural convection in porous media. The numerical solution of volume-averaged Darcy-Oberbeck-Boussinesq (DOB) equations is the most common macroscopic approach, but the DOB equations only account for the microscopic properties of the porous medium via the permeability and effective diffusivity. This simplification may be the reason for the discrepancies between the Sherwood/Nusselt number scaling from DOB simulations and laboratory experiments.
We performed pore-scale-resolving direct numerical simulations (DNS) of turbulent natural convection in a porous medium (Gasow *et al.* 2020). Our DNS results lead to the conclusion that two length scales (the pore scale and the characteristic macroscopic length scale) and the viscous diffusion term, should be explicitly accounted for in the macroscopic equations. Because the DNS results showed that the viscous diffusion term is of the same order of the Darcy number (Da) as well like the buoyancy force term and the Darcy term.
Based on our analysis, we proposed a new macroscopic model the two-length-scale diffusion (TLSD) model, where we assume that pore scale structures affect the momentum transport through macroscopic diffusion. Whereby the macroscopic diffusion is determined by the two length scales, the pore size characterized by the square root of the permeability and the characteristic macroscopic length scale, which is the distance between the lower and upper boundaries.

The results of this model were validated with our DNS results, which were volume-averaged over each representative elementary volume (REV) of the porous medium to obtain the respective macroscopic fields. The comparison shows that our proposed macroscopic model is more accurate than the traditional DOB model and performs well as long as Da 2×10^{-6}. In particular the new model can predict well the phenomenon revealed by our DNS results that the Sherwood ~ Rayleigh number scaling changes from a linear scaling to a non-linear scaling as the porosity increases. The new macroscopic model also predicts well that if the Rayleigh number is fixed, the Sherwood number increases with the increase of the Schmidt number and the decrease of the porosity. These trends agree with the DNS results, whereas they cannot be captured by the DOB simulations.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

Gasow, S., Lin, Z., Zhang, H. C., Kuznetsov, A. V., Avila, M. & Jin, Y. 2020 Effects of pore scale on the macroscopic properties of natural convection in porous media. J. Fluid Mech. 891, A25

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Primary author: Mr GASOW, Stefan (Center of Applied Space Technology and Microgravity (ZARM), University of Bremen)

Co-authors: Dr JIN, Yan (Center of Applied Space Technology and Microgravity (ZARM), University of Bremen); Prof. AVILA, Marc (Center of Applied Space Technology and Microgravity (ZARM), University of Bremen); Prof. KUZNETSOV, Andrey V. (Department of Mechanical and Aerospace Engineering, North Carolina State University)

Presenter: Mr GASOW, Stefan (Center of Applied Space Technology and Microgravity (ZARM), University of Bremen)

Session Classification: Poster +

Track Classification: (MS9) Pore-scale modelling