Towers, John D.

A fixed grid, shifted stencil scheme for inviscid fluid-particle interaction. (English)

Zbl 06638248
Appl. Numer. Math. 110, 26-40 (2016).

Summary: This paper presents a finite volume scheme for a scalar one-dimensional fluid-particle interaction model. When devising a finite volume scheme for this model, one difficulty that arises is how to deal with the moving source term in the PDE while maintaining a fixed grid. The fixed grid requirement comes from the ultimate goal of accommodating two or more particles. The finite volume scheme that we propose addresses the moving source term in a novel way. We use a modified computational stencil, with the lower part of the stencil shifted during those time steps when the particle crosses a mesh point. We then employ an altered convective flux to compensate the stencil shifts. The resulting scheme uses a fixed grid, preserves total momentum, and enforces several stability properties in the single-particle case. The single-particle scheme is easily extended to multiple particles by a splitting method.

MSC:

65 Numerical analysis

Keywords:

solid-fluid interaction; Burgers equation; finite volume scheme; singular source term; moving mesh scheme; well-balanced scheme; moving interface; PDE-ODE coupling

Full Text: DOI

References:

[1] Aguillon, N., Numerical simulations of a fluid-particle coupling, (Finite Volumes for Complex Applications VII-Elliptic, Parabolic and Hyperbolic Problems, Springer Proc. Math. Stat., vol. 78, (2014)), 759-767 · Zbl 1426.76328

[2] Aguillon, N., Riemann problem for a particle-fluid coupling, Math. Models Methods Appl. Sci., 25, 39-78, (2015) · Zbl 1314.35089

[3] Aguillon, N.; Lagoutière, F.; Seguin, N., Convergence of finite volume schemes for coupling between the inviscid Burgers equation and a particle, preprint accessed at · Zbl 1380.65192

[4] Andreianov, B.; Karlsen, K.; Risebro, N., A theory of L^1-dissipative solvers for scalar conservation laws with discontinuous flux, Arch. Ration. Mech. Anal., 201, 27-86, (2011) · Zbl 1261.35088

[5] Andreianov, B.; Lagoutière, F.; Seguin, N.; Takahashi, T., Small solids in an inviscid fluid, Netw. Heterog. Media, 5, 3, 385-404, (2010) · Zbl 1262.35180

[6] Andreianov, B.; Lagoutière, F.; Seguin, N.; Takahashi, T., Well-posedness for a one-dimensional fluid-particle interaction model, SIAM J. Math. Anal., 46, 1030-1052, (2014) · Zbl 1302.35263

[7] Andreianov, B.; Seguin, N., Analysis of a Burgers equation with singular resonant source term and convergence of well-balanced schemes, Discrete Contin. Dyn. Syst., 32, 6, 1939-1964, (2012) · Zbl 1246.35125

[8] Harten, A., High resolution schemes for hyperbolic conservation laws, J. Comput. Phys., 49, 357-393, (1983) · Zbl 0565.65050

[9] Holden, H.; Karlsen, K. H.; Lie, K.-A.; Risebro, N. H., Splitting for partial differential equations with rough solutions, (2010), European Math. Soc. Publishing House Zurich

[10] Lagoutière, F.; Seguin, N.; Takahashi, T., A simple 1D model of inviscid fluid-solid interaction, J. Differ. Equ., 245, 3503-3544, (2008) · Zbl 1151.76033

[11] LeRoux, A., A numerical conception of entropy for quasi-linear equations, Math. Comput., 31, 848-872, (1977) · Zbl 0378.65053

[12] Leveque, R. J., Finite volume methods for hyperbolic problems, (2002), Cambridge University Press Cambridge, UK · Zbl 1010.65040