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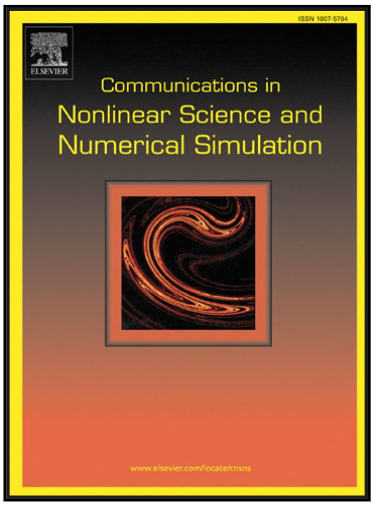

Learning physics by data for the motion of a sphere falling in a non-Newtonian fluid

Zongmin Wu, Ran Zhang

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Highlights

In this paper, based on the physical observations and analyses, a nonlinear differential/algebraic equation of the velocity v of a falling sphere in non-Newtonian fluid will be proposed by directly learning the time vs velocity data. From the numerical results, our model successfully simulates the sustaining oscillations and abrupt increase during the sedimentation of a sphere through a non-Newtonian fluid, and presents the behavior of a chaotic system which is highly sensitive to initial conditions and experimentally non-reproducible. After normalization, it is

$$v = T\frac{dv'' + 1}{v'' + d}v''.$$

Consistent with the experiments, it can be regarded as a nonlinear elastic system, which consists of flow-induced structure formed in the shear region around the sphere and the extensional stress in the wake of the sphere. This normalized representation covers both the classical physical laws and the nonuniform oscillations. Actually, for $d = 0$, it is a constant velocity model, $v = T$, which is coincident with the Stokes law, i.e, the falling sphere reaches a terminal velocity; and for $d = 1$, the model represents a uniform harmonic motion $v = Tv''$.

Now big data has come into being in multi-fields of sciences and engineering. The data-driven idea will provide scientists with more important tools to support their discovery in the future.