MOTION OF A CYLINDER RIGID BODY INTERACTING WITH POINT VORTICES

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The problem of falling motion of a body in fluid has a long history and was considered in a series of the classical and modern papers. Some of the effects described in the papers, such as periodic rotation (tumbling), can be encountered only in viscous fluids and thus demand for their proper treatment the use of the Navier - Stokes equations with boundary conditions specified on the body's surface. As a rule, such problems are hardly amenable to analytical analysis and can be addressed only numerically.

In this work we study the influence of the vorticity on the falling body in a trivial setting: a body (circular cylinder) subject to gravity is interacting dynamically with N point vortices. The circulation around the cylinder is not necessarily zero. So the model we consider here is exact and, at the same time, not so despairingly complex as most of the existing models are. The dynamical behavior of a heavy circular cylinder and N point vortices in an unbounded volume of ideal liquid is considered. The liquid is assumed to be irrotational and at rest at infinity. The circulation about the cylinder is different from zero. The governing equations are presented in Hamiltonian form. Integrals of motion are found. Allowable types of trajectories are discussed in the case of single vortex. The stability of finding equilibrium solutions is investigated and some remarkable types of partial solutions of the system are presented. Poincare sections of the system demonstrate chaotic behavior of dynamics, which indicates a non-integrability of the system.

In a case of zero circulation using autonomous integral we can also reduce the order of the system by one degree of freedom. Unlike nonzero circulation and the absence of vortices when the cylinder moves inside a certain horizontal stripe it is shown that in a presence of vortices and with circulation equal to zero vertical coordinate of the cylinder is unbounded decreasing. We then focus on the numerical study of dynamics of our system. In a case of zero circulation trajectories are noncompact. The different kinds of the scattering function of the vortex by cylinder were obtained. The form of these functions argues to chaotic behavior of the scattering which means that an additional analytical integral is absent.

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REFERENCES

1. *Sokolov S. V., Ramodanov S. M.,* "Falling motion of a circular cylinder interacting dynamically with a point vortex" Regular and Chaotic Dynamics, **18**, No. 1–2, 184–193 (2013).
2. *Sokolov S. V.,* "Falling motion of a circular cylinder interacting dynamically with N point vortices" Nonlinear Dynamics and Mobile Robotics, **2**, No. 2, 99–113 (2014).
3. *Sokolov S. V.,* "Falling motion of a circular cylinder interacting dynamically with a vortex pair in a perfect fluid" Bulletin of Udmurt University. Mathematics, Mechanics, Computer Science, No. 2, 86–99 (2014).
4. *Sokolov S. V., Koltsov I. S.,* "Chaotic scattering of the point vortex by falling circular cylinder" Bulletin of Udmurt University. Mathematics, Mechanics, Computer Science, **25**, No. 2, 184–196 (2015).