Trudy Instituta Matematiki i Mekhaniki UrO RAN

Vol. 29 No. 2 2023

**MSC:** 76N15, 76M60

**DOI**: 10.21538/0134-4889-2023-29-2-207-216

# A PLANAR COLLAPSE OF A GAS WITH A LINEAR VELOCITY FIELD

**L. Z. Urazbakhtina, Yu. V. Yulmukhametova**

Solutions of gas dynamics equations with a linear velocity field and uniform deformation are considered. The linearity matrix is diagonal nondegenerate with different eigenvalues. The state equation is an equation with separated density. The world lines of motion of gas particles are written for a solution of the state equation for a polytropic gas. The motion of particles describes collapses in two mutually perpendicular planes at different times. The motions of bounded specific volumes of particles are shown. The motions of a sonic surface, characteristics, and the characteristic conoid are described. Approximate formulas are given for calculating the motion of characteristics passing through any given surface. An exact solution with nonhomogeneous deformation is obtained for the linearity matrix of the solution without the conditions of density and pressure invariance.

Keywords: gas dynamics, linear velocity field, homogeneous deformation, inhomogeneous deformation, polytropic gas, collapse, characteristics.

## REFERENCES

1. Riemann B. *Ein Beitrag zu den Untersuchungen über die Bewegung einer flüssigen gleichartigen Ellipsoides*, Abh. d. Königl. Gesell. der Wiss. zu Göttingen, 1861.
2. Borisov A.V., Mamaev I.S. (eds.) *Dinamika zhidkikh i gazovykh ellipsoidov* [Dynamics of liquid and gas ellipsoids]. Moscow, Izhevsk, Institut komp'yuternykh issledovanii Publ., 2010. 364 p.
3. Giron J.F., Ramsey S.D., Baty R.S. Nemchinov-dyson solutions of the two-dimensional axisymmetric inviscid compressible flow equations. *Phys. Fluids* , 2020, vol. 32, no. 12, article no. 127116. doi: 10.1063/5.0032170
4. Turzynsky M. Properties of solutions to the gas dynamics equations on a rotating plane, corresponding to motions with homogeneous deformation. *Moscow University Mechanics Bulletin*, 2020, vol. 75, no. 2, pp. 37–43. doi: 10.3103/S002713302002003X
5. Yulmukhametova Yu. V. Submodels in gas dynamics with linear field of velocity. *Sib. Elektron. Mat. Izv.*, 2012, vol. 9, pp. 208-226 (in Russian).
6. Urazbakhtina L. Z. Integrable hydrodynamic submodels with a linear velocity field. *J. Appl. Industr. Math.*, 2013, vol. 7, no. 1. pp. 117–126. doi: 10.1134/S1990478913010110
7. Khabirov S. V. Irregular partially invariant solutions of rank 2 and defect 1 to equations of gas dynamics. *Sib. Math. J.*, 2002, vol. 43, no. 5, pp. 942–954. doi: 10.1023/A:1020119210353
8. Ovsyannikov L.V. *Lektsii po osnovam gazovoi dinamiki* [Lectures on the fundamentals of gas dynamics]. Moscow, Izhevsk, Institut komp'yuternykh issledovanii, 2003, 336 p. ISBN: 5-93972-201-6
9. Khabirov S. V. *Lectsii. Analiticheskie metody v gazovoi dinamike* [Lections. Analytical methods in gas dynamics], Ufa, Bashkir State Univ., 2013, 224 p.
10. Nikonorova R., Siraeva D., Yulmukhametova Y. New exact solutions with a linear velocity field for the gas dynamics equations for two types of state equations. *Mathematics*, 2022, vol. 10, no. 1, article no. 123. https://doi.org/10.3390/math10010123

Received February 2, 2023
Revised April 10, 2023
Accepted April 17, 2023

**Funding Agency:** The work was supported under state contract no. 0246-2019-0052 .

*Lilia Zinphirovna Urazbakhtina,* Cand. Sci. (Phys.-Math.), Ufa University of Science and Technology, Ufa, 450076 Russia, e-mail: ylz@yandex.ru .

*Yuliya Valer'evna Yulmukhametova,* Cand. Sci. (Phys.-Math.), Ufa Mavlyutov Institute of Mechanics – Subdivision of the Ufa Federal Research Centre of the Russian Academy of Sciences, Ufa, 450054 Russia. e-mail: yulmuhametova.yuv@ugatu.su .

Cite this article as: L. Z. Urazbakhtina, Yu. V. Yulmukhametova. A planar collapse of a gas with a linear velocity field. *Trudy Instituta Matematiki i Mekhaniki UrO RAN*, 2023, vol. 29, no. 2, pp. 207–216.