Group-theoretic analysis of Moffatt's problem

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In our talk we consider from group-theoretic point of view a model describing the "skin effect" in a thin surface layer of liquid metals immersed in a high-frequency magnetic field [1]:

$$\psi_y\psi_{xy} - \psi_x\psi_{yy} = \nu\psi_{yyy}, \ (x,y) \in \Omega, \tag{1}$$

$$\psi = 0, \ \psi_y = Ax^m, \quad \text{on} \quad y = 0, \tag{2}$$

$$\psi_y \to 0 \quad \text{as} \quad y \to +\infty, \tag{3}$$

where ψ is a stream function to be determined; $A, \nu > 0, m \neq -1$ are arbitrary real constants obeying the condition: $A > 0$ when $m + 1 > 0$ and $A < 0$ when $m + 1 < 0$; $\Omega = \{(x, y) : -\infty < x < +\infty, 0 < y < +\infty\}$.

The complete Lie group analysis of the boundary value problem (1)–(3) is carried out, namely, we find all Lie's symmetry operators of equation (1), which are compatible with the boundary value problem under study. The exact analytical solutions in closed form of the one are also constructed.

References

[1] H. K. Moffatt, *High-frequency excitation of liquid metal systems*, in: H. K. Moffatt, M. R. E. Proctor (Eds.), IUTAM Symposium: Metallurgical Application of Magnetohydrodynamics, Cambridge Univ. Press, Cambridge, 1984.