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ABSTRACTS

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STABILITY OF SHALLOW WATER FLOW FOR THE CASE OF ASYMMETRIC BASE VELOCITY PROFILE

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Linear stability analysis of shallow flows is usually performed for the case of symmetric base flow velocity profiles (such as hyperbolic tangent velocity profile for mixing layers and hyperbolic secant profile for wakes), see [1]. In some cases, however, symmetry of the base flow can be distorted and the resulting profile can be asymmetric with respect to the transverse coordinate. One important example of such a flow is the flow adjacent to a porous layer (which is represented in practice by terrestial or aquatic vegetation [2]). The resistance within the porous layer creates substantial shear stresses across the interface. Experimental data [2] show that the base flow profile (in the presence of vegetation) has a distinct two-layer structure, that is, in contrast with a classic shear layer it is asymmetric.

The role of asymmetry of the base flow velocity profile on the stability characteristics of shallow water flow is investigated in the present paper. The base flow velocity distribution is modeled by the formula

$$U(y) = U_0(1 + R \tanh \frac{y}{\delta}), \tag{1}$$

where $R = (U_2 - U_1)/(U_2 + U_1)$ is the velocity ratio,U_2 and U_1 are the mean velocities in the open channel and the vegetation, U_0 is the centerline velocity, y is the transverse coordinate and δ is the parameter which has different values in the vegetation and open channel, respectively.

The system of shallow water equations with appropriate boundary conditions is reduced to an eigenvalue problem for a second-order ordinary differential equation by the use of the method of normal modes. The eigenvalue problem is solved by collocation method based on Chebyshev polynomials. After discretization it is reduced to a generalized eigenvalue problem of the form

$$(A - \lambda B)x = 0, \tag{2}$$

where A and B are complex-valued matrices. Problem (2) is solved numerically by one of the routines from IMSL package. Stability chararacteristics of the problem are compared with similar characteristics evaluated for the case of a symmetric base flow velocity profile.

REFERENCES

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