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A fast implicit primal-dual method for steady viscoplastic flows

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Constitutive laws for viscoplastic materials involve a multivalued nonlinearity. Duality methods for such equations are known to converge, but the convergence is slow, the error is in general of the order of $1/k$ with k the number of iterations.
We consider here an iterative method of classical implicit primal-dual type with a particular form with strong implicitation. An analysis via Lyapunov functional yields admissible values of the parameters, whereas a linearized analysis for scalar problems indicates the potentially best values. An adaptive choice of the parameters enables to achieve a fast convergence.
Numerical tests show that we obtain an optimal accuracy in less than five iterations for simple problems, and about fifteen iterations for stiff problems, each iteration having the cost of a Laplace problem. Bingham or Herschel-Bulkley laws are considered.

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