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# Schemes with improving rate of convergence for three-stage Gauss method

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The various iteration schemes have been proposed to solve the nonlinear equations arising in the implementation of $s$-stage implicit Runge-Kutta methods applied to solve a system of $n$ ordinary differential equations with initial conditions $y'(x) = f(y(x))$ ; $a \leq x \leq b,\ y : [a, b] \longrightarrow \mathbb{R}^n, y(a) = \gamma$ and $f : \mathbb{R}^n \longrightarrow \mathbb{R}^n$.

A more general scheme, which was already proposed, is given by $\{I_s \otimes (I_n - h\lambda \otimes J)\}E^m = (BS^{-1} \otimes I_n)D(Y^{m-1}) + (L \otimes I_n)E^m, Y^m = Y^{m-1} + (S \otimes I_n)E^m, m = 1,2,3, \ldots$, where $B$ and $S$ are real non-singular parametric matrices, $L$ is a strictly lower triangular matrix, $J$ is the Jacobian evaluated at some recent point $x_p$, $h$ is a fixed step size, $I_s$ and $I_n$ are identity matrices with order $s$ and $n$ respectively, $S \otimes I_n$ is the direct product of $S$ with $I_n$ and $\lambda$ is a real constant and $D(Y^{m-1})$ is the approximate diffect correction given by $D(Y^{m-1}) = X - Y^{m-1} + h(A \otimes I_n)F(Y^{m-1})$ , where $A$ is a coefficient matrix of the method, and $F(Y) = f(y_1) \oplus f(y_2) \oplus f(y_3) \oplus \ldots \ldots \oplus f(y_s)$ is $sn$ column vector.

The rate of convergence of this scheme is examined when it is applied to the scalar differential equations $x' = qx$ and the rate of convergence depends on the spectral radius $\rho[M(z)]$ of the iteration matrix $M(z)$, a function of $z = hq$, where $h$ is a fixed step size. This scheme had already been investigated by assuming that $M(z)$ has only one non-zero eigen-value. In this problem, this scheme is further investigated by forcing $\rho[M(z)]$ to be zero at $z = 0$ and to be zero at $z = \infty$ in addition to the constraint that $M(z)$ has only one non-zero eigenvalue. Results are obtained for three-stage Gauss method. A number of numerical experiments are carried out to confirm the results obtained for three stage Gauss method.

**Keywords**: Stiff system, Optimal value, Spectral radius, Gauss method.